THE
POPULAR SCIENCE
MONTHLY.

FEBRUARY, 1903

THE SCIENCE OF ASTRONOMY.*

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I TAKE for the subject of my address the science of astronomy, and propose to give a brief historical sketch of it, to consider its future development, and to speak of the influence of the sciences on civilization.

The science of astronomy is so closely connected with the affairs of life, and is brought into use so continuously and in such a systematic manner, that most people never think of the long labor that has been necessary to bring this science to its present condition. In the early times it was useful to the legislator and the priest, for keeping records, the times of public ceremonies and of religious festivals. It slowly grew into the form of a science, and became able to make predictions with some certainty. This was many centuries ago; Hipparchus, who lived 150 B. C., knew the periods of the six ancient planets with considerable accuracy. His periods are:

	Period.	$\frac{\text{Error} \times 100}{\text{Period}}$
Mercury	87d.9698	+ 0d.0007
Venus	224.7028	+ 0.0009
Earth	365.2599	+ 0.0010
Mars	686.9785	— 0.0002
Jupiter	4332.3192	— 0.0061
Saturn	10758.3222	— 0.0083

These results indicate that more than two thousand years ago there existed recorded observations of astronomy. Hipparchus appears to have been one of those clear-headed men who deduce results from observations with good judgment. There was a time when those ancient

* Address of the President of the American Association for the Advancement of Science, Washington meeting, December 29, 1902.

Greek astronomers had conceived the heliocentric motions of the planets, but this true theory was set aside by the ingenious Ptolemy, who assumed the earth as the center of motion, and explained the apparent motions of the planets by epicycles so well that his theory became the one adopted in the schools of Europe during fourteen centuries. The Ptolemaic theory flattered the egotism of men by making the earth the center of motion, and it corresponded well with old legends and myths, so that it became inwoven with the literature, art and religion of those times. Dante's construction of Hell, Purgatory and Paradise is derived from the Ptolemaic theory of the universe. His ponderous arrangement of ten divisions of Paradise, with ten Purgatories and ten Hells, is said by some critics to furnish convenient places for Dante to put away his friends and his enemies, but it is all derived from the prevailing astronomy. Similar notions will be found in Milton, but modified by the ideas of Copernicus, which Milton had learned in Italy. The Copernican theory won its way slowly, but surely, because it is the system of nature, and all discoveries in theory and practical astronomy helped to show its truth. Kepler's discoveries in astronomy, Galileo's discovery of the laws of motion and Newton's discovery of the law of gravitation, put the Copernican theory on a solid foundation. Yet it was many years before the new theories were fully accepted. Dr. Johnson thought persecution a good thing, since it weeds out false men and false theories. The Copernican and Newtonian theories have stood the test of observation and criticism, and they now form the adopted system of astronomy.

The laws of motion, together with the law of gravitation, enable the astronomer to form the equations of motion for the bodies of our solar system; it remains to solve these equations, to correct the orbits, and to form tables of the Sun, Moon and the planets. This work was begun more than a century ago, and it has been repeated for the principal planets several times, so that now we have good tables of these bodies. In the case of the principal planets the labor of determining their orbits was facilitated by the approximate orbits handed down to us by the ancient astronomers; and also by the peculiar conditions of these orbits. For the most part the orbits are nearly circular; the planets move nearly in the same plane, and their motions are in the same directions. These are the conditions Laplace used as the foundation of the nebular hypothesis. With approximate values of the periods and motions, and under the other favoring conditions, it was not difficult to form tables of the planets. However the general problem of determining an orbit from three observations, which furnish the necessary and sufficient data, was not solved until about a century ago. The orbits of comets were first calculated with some precision. Attention was called to these bodies by their threatening aspects, and by the terror they inspired

among people. It was therefore a happy duty of the astronomers to show that the comets also move in orbits around the Sun, and are subject to the same laws as the planets. This work was easier because the comets move nearly in parabolas, which are the simplest of the conic sections. Still the general problem of finding the six elements of an orbit from the six data given by three observations remained to be solved. The solution was given by Gauss a century ago in a very elegant manner. His book is a model, and one of the best ever written on theoretical astronomy. No better experience can be had for a student than to come in contact with such a book and with such an author. The solution of Laplace for the orbit of a comet is general, but demands more labor of computing than the method of Olbers, as arranged by Gauss. It is said by some writers that the method of Laplace is to be preferred because more than three observations can be used. In fact this is necessary in order to get good values of the derivatives of the longitudes and latitudes with respect to the time, but it leads to long and rather uncertain computations. Moreover it employs more data than are necessary, and thus is a departure from the mathematical theory of the problem. This method is ingenious, and by means of the derivatives it gives an interesting rule for judging of the distance of a comet from the earth by the curvature of its apparent path, but a trial shows that the method of Olbers is much shorter. Good preliminary orbits can now be computed for comets and planets without much labor. This, however, is only a beginning of the work of determining their actual motions. The planets act on each other and on the comets, and it is necessary to compute the result of these forces. Here again the conditions of our solar system furnish peculiar advantages. The great mass of the sun exerts such a superior force that the attractions of the planets are relatively small, so that the first orbits, computed by neglecting this interaction, are nearly correct. But the interactions of planets become important with the lapse of time, and the labor of computing these perturbations is very great. This work has been done repeatedly, and we now have good numerical values of the theories of the principal planets, from which tables can be made. Practically, therefore, this question appears to be well toward a final solution. But the whole story has not been told.

The planets, on account of their relative distances being great and because their figures are nearly spherical, can be considered as material particles and then the equations of motion are readily formed. In the case of n material particles acting on each other by the Newtonian law, and free from external action, we shall have $3n$ differential equations of motion, and $6n$ integrations are necessary for the complete solution. Of these only ten can be made, so that in the case of only three bodies there remain eight integrations that cannot be found. The early

investigators soon obtained this result, and it is clearly stated by Lagrange and Laplace. The astronomer, therefore, is forced to have recourse to approximate methods. He begins with the problem of two bodies, the sun and a planet, and neglects the actions of the other planets. In this problem of two bodies the motions take place in a plane, and the integrations can all be made. Two constants are needed to fix the position of the plane of motion, and the four other constants pertaining to the equations in this plane are easily found. This solution is the starting point for finding the orbits of all the planets and comets. The mass of the sun is so overpowering that the solution of the problem of two bodies gives a good idea of the real orbits. Then the theory of the variation of the elements is introduced, an idea completely worked out into a practical form by Lagrange. The elements of the orbits are supposed to be continually changed by the attractions of the other planets. By means of this theory, and the mathematical machinery given by Lagrange, which can be applied to a great variety of questions, the observations of the planets can be satisfied over long intervals of time. When this theory of the motions was carried out a century ago it appeared that the great problem of planetary motion was near a complete solution. But this solution depends on the use of series, which undergo integrations that may introduce small divisors. An examination of these series by Hansen, Poincaré and others indicates that some of them are not convergent. Hence the conclusions formerly drawn about the stability of our solar system are not trustworthy, and must be held in abeyance. But looking at the construction of our system, and considering the manner in which it was probably evolved, it appears to be stable. However the mathematical proof is wanting. In finding the general integrals of the motions of n bodies, the assumption that the bodies are particles gets rid of the motions of rotation. These motions are peculiar to each body, and are left for special consideration. In the case of the earth this motion is very important, since the reckoning of time, one of our fundamental conceptions, depends on this motion. Among the ten general integrals that can be found six belong to the progressive motion of the system of bodies. They show that the center of gravity of the system moves in a right line, and with uniform velocity. Accurate observations of the stars now extend over a century and a half, and we are beginning to see this result by the motion of our sun through space. So far the motion appears to be rectilinear and uniform, or the action of the stars is without influence. This is a matter that will be developed in the future. Three of the other general integrals belong to the theory of areas, and Laplace has drawn from them his theory of the invariable plane of the system. The remaining integral gives the equation of living force. The question of relative motion remains, and is the problem of theoretical astronomy.

This has given rise to many beautiful mathematical investigations, and developments into series. But the modern researches have shown that we are not sure of our theoretical results obtained in this way, and we are thrown back on empirical methods. Perhaps the theories may be improved. It is to be hoped that the treatment of the differential equations may be made more general and complete. Efforts have been made in this direction by Newcomb and others, and especially by Glydèn, but so far without much practical result.

The problem of three bodies was encountered by the mathematicians who followed Newton, and many efforts were made to solve it. These efforts continue, although the complete investigations of Lagrange appear to put the matter at rest. The only solutions found are of very special character. Laplace used one of these solutions to ridicule the doctrine of final causes. It was the custom to teach that the moon was made to give us light at night. Laplace showed by one of the special solutions that the actual conditions might be improved, and that we might have a full moon all the time. But his argument failed, since such a system is unstable and cannot exist in nature. But some of the efforts to obtain partial solutions have been more fruitful, and G. W. Hill has obtained elegant and useful results. These methods depend on assumed conditions that do not exist in nature, but are approximately true. The problem of two bodies is a case of this kind, and the partial solutions may illustrate, but will not overcome, the fundamental difficulty.

The arrangement of our solar system is such that the distances of the planets from one another are very great with respect to their dimensions, and this facilitates very much the determination of their motions. Should two bodies approach very near each other the disturbing force might become great, even in the case of small masses. In the case of comets this condition happens in nature, and the comet may become a satellite of a planet, and the sun a disturbing body. In this way it is probable that comets and meteoric streams have been introduced into our solar system. We have here an interesting set of problems. This question is sometimes treated as one of statics, but since the bodies are in motion it belongs to dynamics. Further study may throw light on some relations between the asteroids and the periodical comets.

The great question of astronomy is the complete and rigorous test of the Newtonian law of gravitation. This law has represented observations so well during a century and a half that it is a general belief that the law will prove true for all time, and that it will be found to govern the motions of the stars as well as those of our solar system. The proof is cumulative and strong for this generality. It will be a wonderful result if this law is found rigorously true for all time and throughout the universe. Time is sure to bring severe tests to all theories. We

know that the law of gravitation is modified in the motions of the matter that forms the tails of comets. There is an anomaly in the theory of Mercury which the law does not explain, and the motion of our moon is not yet represented by theory. The lunar theory is very complicated and difficult, but it does not seem probable that the defect in Hansen's theory will be found by recomputing the periodical coefficients, that have been already computed by many mathematicians and astronomers, and with good agreement by Hansen and Delaunay, by very different methods. Hansen was a computer of great skill, but he may have forced an agreement with observations, from 1750 to 1850, by using a coefficient of long period with an erroneous value. No doubt the error of this theory will be discovered. Back of all theories, however, remains the difficulty of solving the equations of motion so that the result can be applied with certainty over long periods of time. Until this is done we shall not be able to subject our law to a crucial test.

The constants that enter the theories of the planets and moon must be found from observations. In order to compare observations made at distant epochs, the motions of the planes of reference must be known with accuracy, and also the motion of our solar system in space. As the stars are our points of reference their positions and their proper motions must be studied with great care. This department of astronomy was brought to a high degree of order by the genius of Bessel, whose work forms an epoch in modern astronomy. The recent progress made in determining the positions of the stars in all parts of the heavens will be a great help to the investigations of the future. We must have observatories where accurate and continuous observations are made. Our country is well situated to supplement the work of Europe, and we hope it will never fail to add its contribution to the annals of astronomy. American astronomers should keep pace in the improvements for increasing the ease and accuracy of making observations. The spectroscope has given a new element in the motions of the stars, not to speak of the interesting physical results obtained by its use. Photography will give great aid in determining the relative positions of the stars and in forming maps of the heavens. All new methods, however, will need examination and criticism, since they bring new sources of error. Fifty years ago it was thought the chronograph would increase very much the accuracy of right ascensions. It has not done this directly to any great extent, but it has increased the ease and rapidity of observing. We must remember that astronomical results finally depend on meridian observations, and that it is the duty of astronomers to make these continuous from generation to generation. In this way we shall gain the powerful influence of time to help control and solve our problems. There is one point where a reform may be needed from the dead weight of the large and expanding volumes sent

forth by observatories and scientific institutions. The desire for publication is great, but the results should be well discussed and arranged, so that the printing may be shortened. Otherwise our publications may become burdensome, and when they are piled up in libraries some future Caliph Omar may be tempted to burn them. Even mathematics appears to labor under a similar oppression, and much of its printed matter may be destined to molder to useless dust.

In the not distant future stellar astronomy will become a great and interesting field of research. The data for the motions of the stars are becoming better known, but these motions are slow, and the astronomer of to-day looks with envy on the astronomer of a thousand years hence, when time will have developed these motions. Much may be done by the steady and careful work of observation and discussion, and the accumulation of accurate data. Here each one of us can add his mite. But the great steps of progress in science have come from the efforts of individuals. Schools and universities help forward knowledge by giving to many students opportunities to learn the present conditions, and from them some genius like Lagrange or Gauss may come forth to solve hard questions, and to break the paths for future progress. This is about all the schools can do. We need a body of men who can give their lives to quiet and continuous study. When the young Laplace was helped to a position where he could devote his life to research D'Alembert did more for the progress of astronomy than all the universities of Europe.

One needs only to glance at history to see how useful astronomy has been in the life of the world. It has wonderfully enlarged the universe, and widened the views of men. It shows how law and order pervade the world in which we live; and by the knowledge it has disseminated and by its predictions it has banished many superstitions and fears. The sciences will continue to grow; and they will exert the same influence. The erroneous and dogmatic assertions of men will be pushed aside. In our new country the energies of the people are devoted chiefly to commercial and political ends, but wealth is accumulating, leisure and opportunity will come, and we may look forward to a great development of scientific activity. We must be patient. Men do not change much from generation to generation. Nations that have spent centuries in robbery and pillage retain their dispositions and make it necessary for other nations to stand armed. No one knows when a specious plea for extending the area of civilization may be put forth, or when some fanatic may see the hand of God beckoning him to seize a country. The progress of science and invention will render it more difficult for such people to execute their designs. A century hence it may be impossible for brutal power, however rich and great, to destroy a resolute people. It is in this direction that we may look for

international harmony and peace, simply because science will make war too dangerous and too costly.

The influence of the sciences in bringing men of different nationalities into harmony is great. This is done largely by the common languages that are formed in each science. In mathematics the language is so well formed and generally adopted that mathematicians all over the world have no trouble in understanding one another. It may be difficult to read Russian, but every one can read the formulas of Tchebitchef and Lobaschewsky. In astronomy the common language is nearly as well established, so that there is little difficulty in understanding the astronomy of different nations. A similar process is going on in chemistry, botany and in the other sciences. When men are striving for the discovery of truth in its various manifestations, they learn that is is by correcting the mistakes of preceding investigators that progress is made, and they have charity for criticism. Hence persecution for difference of opinion becomes an absurdity. The labors of scientific men are forming a great body of doctrine that can be appealed to with confidence in all countries. Such labors bring people together, and tend to break down national barriers and restrictions. The scientific creed is constantly growing and expanding, and we have no fears, but rejoice at its growth. We need no consistory of bishops, nor synod of ministers, to tell us what to believe. Everything is open to investigation and criticism.

In our country we have one of the greatest theaters for national life that the world has ever seen. Stretching three thousand miles from ocean to ocean, and covering the rich valleys of the great rivers, we have a land of immense resources. Here is a vast field for scientific work of various kinds. No doubt the men of the future will be competent to solve the problems that will arise. Let us hope that our national character will be just and humane, and that we may depart from the old custom of robbing and devouring weak peoples. Any one who saw the confusion and waste in this city in 1862 might well have despaired of the Republic; and he who saw the armies of Grant and Sherman pass through the city in 1865 felt that he need fear no foreign foe: neither French emperor, nor English nobleman nor the sneers of Carlyle. To destroy a democracy by external force the blows must be quick and hard, because its power of recuperation is great. The danger will come from internal forces produced by false political and social theories, since we offer such a great field for the action of charlatans. Our schools and colleges send forth every year many educated people, and it is sometimes disheartening to see how little influence these people have in public life. Those who are trained in the humanities and churches ought to be humane in dealing with other people, ready to meet great emergencies and powerful to control bad

tendencies in national affairs. But this is rarely the case. On the other hand the most unscrupulous apologists and persecutors have been educated men, and the heroes of humanity have come from the common people. This anomaly points to something wrong in the system of education, which should disappear. The increase and teaching of scientific ideas will be the best means of establishing simple and natural rules of life. Nature, and science her interpreter, teach us to be honest and true, and they lead us to the Golden Rule.

THE EVOLUTION OF SEX IN PLANTS.

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IN a former paper published in The Popular Science Monthly* we considered the origin of sex in plants, describing the progenitors of the sexual elements or gametes and some of the conditions under which these cells assume sexual characters. No attempt was made to trace the later history of these primitive gametes as they become differentiated into the two extremes of sexual cells, the egg and sperm. This is a subject quite independent of the origin of sex and deserves the separate treatment that we are now to present.

Primitive gametes are sexual cells so similar in size, form and internal structure that they cannot be distinguished as male or female. They are found in a number of the lower groups of algae and have the general appearance and same mode of formation as the zoospores from which they have been derived. Excellent illustrations are presented by *Ulothrix, Cladophora, Hydrodictyon, Ulva* and *Ectocarpus*. In these types the gametes are small motile cells, generally formed numerously in the mother cell or gametangium and discharged into the water where they conjugate in pairs. The principal events of their formation and behavior are illustrated for *Cladophora* and *Ulva* in Fig. 1. In my former paper I described and figured the conditions for *Ulothrix* and *Hydrodictyon*. (Popular Science Monthly, November, 1901, pp. 70–73, figs. 2 and 3.)

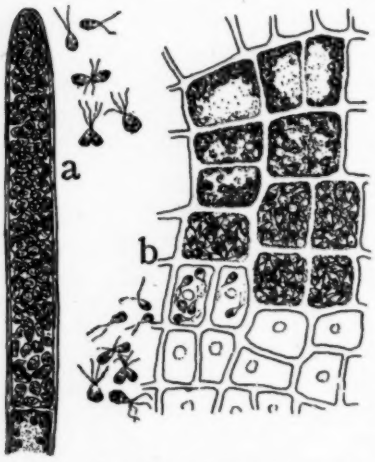

Fig. 1. Gametes and Gametangia of (*a*) *Cladophora*, (*b*) *Ulva*.

Any one familiar with the examples mentioned above will note immediately that they are representatives of diverse groups which are not closely related to one another. On the contrary, most of the forms are associated with very clearly marked divergent lines of development.

* Davis: 'The Origin of Sex in Plants,' Popular Science Monthly, November, 1901, p. 66.

This is important, for it shows that sex did not arise at one period only and at a certain level of the plant kingdom, but, on the contrary, at a number of totally distinct times and in connection with as many independent lines of ascent. We can see no reason why zoospores might not at any time take on the attributes of sex, for the latter conditions are controlled and probably in large measure developed by the chemical and physical environment of the plant. Although sex has arisen a great many times in the plant kingdom and in groups independent of one another, the steps in the process and the structure of the primitive gametes are essentially the same in all cases. There are good reasons for believing that even now certain groups of the algae are developing sexuality, and that this process may be expected to continue wherever the lower algae have the habit of reproducing by zoospores.

With the origin of sex in any group of plants there is immediately presented the possibility of such further evolution as will give the differentiated and highly specialized sexual cells, the eggs and sperms. This evolutionary history is briefly expressed as the development of heterogamy from isogamy or the oosporic type of reproduction from the zygosporic.

Isogamy is the term applied to conditions in which the sexual cells are similar in form, morphologically identical. Heterogamy is the condition in which the female gamete is a motionless cell without cilia and the male gamete generally a ciliated sperm frequently highly specialized in form. Our problem is to understand the steps in the evolution of heterogamy from isogamy and, as far as possible, the factors influential in the process.

Isogamy is a condition very generally distributed among the various groups of algae. We may find it in almost all lines of ascent above the unicellular forms and it is not uncommon among these. Heterogamy always appears at higher levels of development than isogamy and in connection with general advances in vegetative complexity.

It customary to speak of the forms expressing the highest development of evolutionary lines as climax types. Climax types among the algae are almost all heterogamous. There are a few lines in which this level of sexual evolution has not been attained, as for example, the pond scums (Conjugales), the Hydrodictyaceae, Ulvaceae and several smaller groups of the lower algae. On the other hand, there are several heterogamous types standing quite by themselves as the final expression of certain lines of evolution that we can only conjecture because the lower representatives have become extinct. Notable illustrations of this character are the stoneworts (Charales) and the Oedogoniaceae.

Among the remaining groups of algae, and containing by far the greatest portion of this class, are a number of orders and families comprising isogamous and heterogamous forms clearly related in various ways to one another, by vegetative structure and similar life-histories, but offering a wide range of variation in the form and habits of the sexual cells. And it is among these algae that we may find material upon which to base general conclusions on the sexual evolution of plants. These processes are illustrated more or less completely by stages in several groups, but especially so in three lines of development which we shall use as the illustrative basis of this paper. They are the Volvocaceae, certain groups of the brown algae (Phaeophyceae) and the region of the green algae comprising the Ulothricaceae, Chaetophoraceae and Coleochaetaceae.

These three lines are very far removed from one another and must have become separated at an exceedingly early period of development, probably before the origin of sex and certainly before any extended sexual evolution. The Volvocaceae is an extreme side line, by which we mean that its higher members are very far removed from the theoretical main line of ascent that runs through the algae to the next higher group of plants, the Bryophytes. The groups of the Phaeophyceae form a system of side lines very much more highly organized vegetatively than the Volvocaceae. The Ulothricaceae, Chaetophoraceae and Coleochaetaceae are the nearest of all algae to the theoretical main line of ascent, and some of their representatives are very close to this chain of extinct forms; it is, of course, too much to expect that any living alga should be actually one of the links. Each of these three series tells the same story of the general events of sexual evolution as do all other lines of ascent among the algae, fragmentary though some of them are.

We shall take up the Volvocaceae first. This is a peculiar family of plants, remarkable for the fact that the vegetative conditions are motile. Its highest member and a well-defined climax type is *Volvox,* one of the most highly specialized of the algae in its peculiar way. The lowest representatives of the Volvocaceae are unicellular (*Chlamydomonas, Sphaerella,* etc.), and between these simple organisms and the complex *Volvox* there is a series of forms, all cell colonies (*Gonium, Pandorina, Eudorina* and *Pleodorina*), each more complex than the other as to the number, arrangement and degree of specialization of the cells. I know of no family of plants that illustrates so many important evolutionary principles as clearly as the Volvocaceae, and it might be made the subject of an interesting paper. But we are to consider now only the differentiation of the sexual cells.

The lower members of the Volvocaceae are mostly isogamous. In

Sphaerella a large number of gametes (32–64) are formed in a mother cell. These sexual cells are quite similar in size and form, and when they conjugate no one could assert a difference in sex. Most species of *Chlamydomonas* resemble *Sphaerella* in having gametes essentially

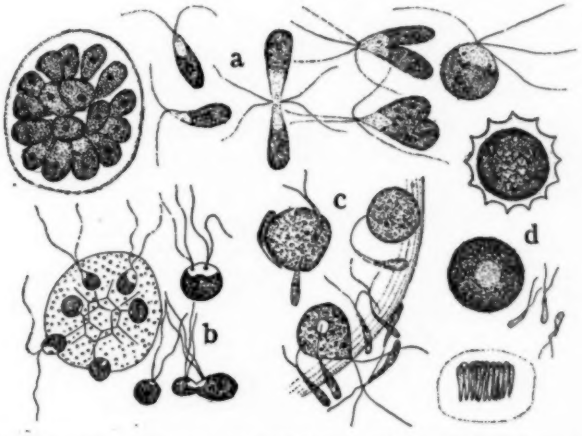

FIG. 2. GAMETES AND GAMETANGIA OF THE VOLVOCACEAE; *a*, *Chlamydomonas Steinii*; *b*, *Pandorina*; *c*, *Eudorina*; *d*, *Volvox*. (*a*, after Goroschankin; *b*, Pringsheim; *c*, Goebel.)

similar (see Fig. 2, *a*), but there are forms in this genus presenting a marked advance. In *Chlamydomonas Braunii** the gametes are of two sizes and the smaller always unite with the larger. However, both are ciliate and consequently motile, so that morphologically they are similar, although there can be no doubt of the sexual differentiation. It is not customary to call the female cell an egg until it has lost its free swimming possibilities and as a passive cell awaits the specialized motile sperm.

Pandorina, like *Sphaerella,* produces a large number of gametes, 16–32 in the mother cell, but here there is a considerable range of variation in the size of the sexual elements, although the form is always the same. Sometimes these gametes will pair, a small one with a larger (see Fig. 2, *b*), as in *Chlamydomonas Braunii,* thus showing the tendency towards sexual differentiation. However, there is no rule in this habit of *Pandorina,* for frequently gametes of equal size conjugate, and one can not assert that the larger cells are always destined to be female sought by smaller male elements. What determines the variation in size of the gametes in *Chlamydomonas Braunii* and *Pandorina,* and the consequent differentiation in sex? It depends entirely on the number of gametes formed in the mother cells and on the size of the latter. The larger female gametes are formed less numerously and generally in larger mother cells and conse-

* Figured in POPULAR SCIENCE MONTHLY, November, 1901, p. 67.

quently receive two to four times more protoplasma and food material than the smaller male gametes. This is an important distinction and fundamental to all sexual evolution. The differentiation of one of the gametes as the cell specialized to hold the greater part of the food supply marks the first step in the series of changes that follow.

Eudorina and *Volvox* are heterogamous. The eggs are large, the sperms highly specialized (see Fig. 2, *c* and *d*) and in all respects the differentiation of sex seems to be carried about as far as in any group of algae. The eggs are formed singly in the mother cell (oogonium), which means that all the protoplasm and all the food available is reserved for that gamete and this is a great advance over the lower types of the Volvocaceae. The sperms are produced abundantly in each antheridium, 64 in *Eudorina* and sometimes more than 200 in *Volvox*. Naturally one would expect the sperms to be minute and they are proportionally very many times smaller in relation to these eggs than the male gametes of *Chlamydomonas* are to the female.

The condition of heterogamy and its advance over isogamy is the result of several well-defined factors at work wherever sex is present. It is advantageous to specialize one gamete for the purpose of holding as much nourishment as possible, thereby providing well for the vegetative possibilities of the next generation. The most effective way to accomplish this end is to reduce the number of female gametes produced in each oogonium, and the best results will obtain when all the protoplasm from such a mother cell goes to a single female gamete. The absence of motility characteristic of eggs is an accompaniment of the increased food supply. It is a very natural condition and advantageous to the species. In the first place large cells can not move through the water as easily as small cells, and again most of the higher algae have the habit of retaining the eggs in oogonia, protecting them in that way for long periods and of course such eggs must naturally be quiescent. With respect to sperms the evolutionary tendencies are very easily understood. Relieve them of the responsibility of contributing much food material to the egg and it is obviously a great advantage to the organism that sperms be produced as numerously as possible, consistent with economy of energy. This demands the reduction in size of the sperm and also results in that high specialization of form so characteristic of motile male elements.

It is evident that all the factors work for the good of the species and are so vital in their bearings as to fall well within the sphere of natural selection. There are doubtless physiological principles taking part in the developmental processes of gamete formation, and at the higher levels of sexual differentiation important factors of heredity. But these have not been very clearly separated, except that the egg

is commonly considered as lacking certain energy which is supplied by the protoplasm (kinoplasm) of the male cell. The sperm, on the other hand, while replete with energy, is ill supplied with nutritive protoplasm (trophoplasm) characteristic of the egg. The phenomenon of parthenogenesis and the recent work on artificial parthenogenesis in animal types show that the energy in the egg may be liberated and the wheels of development set in motion by the proper chemical and physical environment without the intervention of the sperm. But generally the sperm is required to start the egg into activity, and complete and normal development in most organisms probably requires fertilization.

Although most of the stages of sexual evolution are presented in the Volvocaceae, one important stage is there lacking which is especially well illustrated among the brown algae and in the Chaetophoraceae. This is the period of transition from the large free-swimming female gamete to the motionless egg, and covers that evolutionary forward step when the female gamete gives up its motility and the independence of its ancestor the zoospore and becomes the passive receptive egg.

The brown algae (Phaeophyceae) probably developed as an offshoot from the green algae (Chlorophyceae) at a level considerably above the unicellular forms. The lower members of this group are generally well developed filamentous types or more elaborately organized fronds of considerable thickness. Isogamy is general among the lower forms and heterogamy is characteristic of the highest groups (Fucales and Dictyotales). The sexual conditions among the lower groups are especially well exemplified in the genus *Ectocarpus,* whose species present a remarkable series of stages illustrating sexual evolution. The gametes are biciliate cells produced in peculiar types of gametangia which are modified branches whose cells become divided into an immense number of cubical compartments, each of which develops a single gamete. This type of structure is peculiar to the brown algae and is called the plurilocular sporangium or gametangium. It is one of the most interesting organs in the whole group of the Thallophytes because its structure throws light on the difficult problem of the origin of the archegonium.

Some species of *Ectocarpus* have gametes so nearly the same size as to be indistinguishable, but the genus as a whole is remarkable for certain variations in this particular. The plurilocular sporangia are frequently of three distinct sizes, and the zoospores that come from them vary accordingly. It is not always necessary that these zoospores from plurilocular sporangia conjugate in order to grow. There is a great amount of parthenogenetic development depending on environmental conditions that are in part understood. Thus cool temperature and bright illumination tend to suppress sexuality in these zoospores,

making them neutral. In other words, sex in *Ectocarpus* is at such a low level of differentiation that its characteristics are still under the potent influence of external factors, and zoospores that will be sexual under certain conditions, *e. g.*, high temperature, will germinate parthenogenetically if this environment is not present. *Ectocarpus* is then another illustration with *Ulothrix* and *Hydrodictyon* of that primitive state, considered in my former paper, when the asexual zoospore became the gamete under the influence of external factors.

But when the zoospores of *Ectocarpus* have sexuality there is a decided tendency for the smaller gametes to seek the larger more slowly swimming elements and fuse with them. The small gametes have, therefore, male characteristics, which is further shown by the fact that they are unable to develop parthenogenetically or, if they do so, grow into small plants much weaker than the normal.

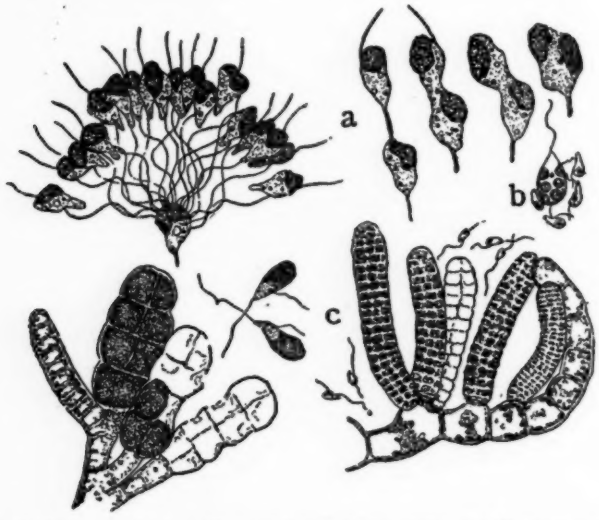

FIG. 3. *a*, *Ectocarpus siliculous*, FEMALE GAMETE SURROUNDED BY MALE, STAGES IN THE FUSION OF GAMETES. *b*, *Ectocarpus secundus*, showing the two sizes of the gametes; *c*, *Cutleria multifida*, male and female gametes and gametangia. (*a*, after Berthold; *b*, Sauvageau; *c* Thuret.)

And now we may consider a habit peculiar to certain species of *Ectocarpus* which is of great interest as an important stage in the process of sexual evolution. It has been most thoroughly studied in *Ectocarpus siliculosus*. The female gametes of this species have a limited period of motility. They swim about slowly and shortly come to rest, attaching themselves. The male gametes are motile for a much longer time. While at rest the female gametes attract the males which hover around (see Fig. 3, *a*), with the result that one fuses with a motionless cell and fertilizes it. This is an exceedingly interesting

condition and furnishes the last link in the chain of stages through which gametes pass in their sexual evolution. The gametes of *Ectocarpus siliculosus* are morphologically isogamous, *i. e.*, both are biciliate cells similar in form when first set free from their respective gametangia. At the time of fusion, however, the condition is physiologically that of heterogamy, for the female cell is essentially a quiescent egg sought by motile sperms. There are species of *Ectocarpus* whose gametes have habits similar to *siliculosus* and which are also of two sizes (see Fig. 3, *b*), so that the resemblance to egg and sperm at the time of fertilization is very marked.

Another brown alga should be considered in connection with the forms noted above. *Cutleria* represents a family quite removed from the Ectocarpaceae and much more highly organized. The gametes differ greatly in size as do also the respective gametangia in appearance (see Fig. 3, *c*). The female gamete is exceptionally large and deeply colored, the male small and almost colorless. At certain seasons of the year (late summer and autumn on the coast of France and England) the female gametes germinate parthenogenetically. If sexual it moves about for a short time and then comes to rest, when it is fertilized as a quiescent cell. The conditions are then the same as in the species of *Ectocarpus* previously described.

Before leaving the brown algae, I am tempted to call attention to a very interesting condition in the group of the kelps (Laminariales). These forms are structurally very complex and are unequaled among the algae in size and luxuriance. But the zoospores of the kelps are never sexual, as far as is known, and the group is conspicuous as a wonderfully successful assemblage that has established itself in nature without the advantage of sexuality, which some biologists have supposed to be absolutely necessary for the high development of any group of organisms. The genus *Caulerpa* among the green algae presents a similar illustration.

We are now ready to examine certain groups of the green algae (Chlorophyceae). There are three families above the unicellular algae that are certainly nearer the main line of ascent than any other groups. They are related to one another and present an ascending scale in vegetative and sexual complexity. The Ulothricaceae, typified by *Ulothrix*, is the lowest group. They are isogamous and illustrate especially well the origin of sex as described in my former paper (POPULAR SCIENCE MONTHLY, November, 1901, pp. 70 and 71). The Chaetophoraceae are likewise isogamous, but sex is more firmly established in this group, and structurally its members (*Draparnaldia, Chaetophora, Stigeoclonium*, etc.) are much more elaborate than the forms of the Ulothricaceae. The Coleochaetaceae end the series with an heterogamous type of considerable complexity.

Among the Chaetophoraceae is the genus *Aphanochaete* (see Fig. 4), presenting one of the most interesting stages of sexual evolution and bridging over a very important gap. *Aphanochaete* develops its female gamete singly in a mother cell. It is discharged into the water surrounded by a delicate vesicle. The gamete, although very large, is ciliate. However, it moves about scarcely at all, and does not leave the vesicle. The sperms gather around the dissolving vesicle, and finally one pierces it and fuses with the female gamete. The fertilized egg immediately begins to turn on its axis and moves about in the water for a few moments and then settles down to rest. It is probable that the cilia remain on the egg for this short period of motility, but it is evident that the female gamete has entirely given up the free-swimming habit. But what is more important, the oogonium appears to deliver its gamete with reluctance, for it is not entirely freed from its investing membrane

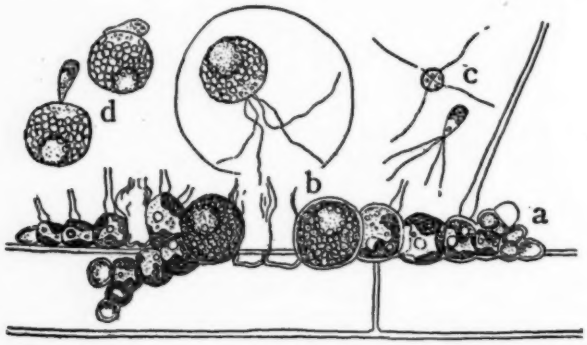

FIG. 4. *Aphanochaete repens; a*, antheridia; *b*, oogonia; *c*, sperms; *d*, eggs. (After Huber.)

until after fertilization. It would be but a small step for *Aphanochaete* to retain this female gamete in the oogonium as a motionless egg and thereby present the furthest extreme of heterogamy. Such a condition would place *Aphanochaete* very close to *Coleochaete,* which it strikingly resembles in some important respects.

The last form in this series of green algae is *Coleochaete,* the sole representative of the family Coleochaetaceae. Of all the algae this type probably stands the closest to the liverworts, not because its sexual organs are similar, but because it presents a sphorophyte generation resembling that of the lowest liverworts (Ricciales). *Coleochaete* is heterogamous, but its sexual organs can scarcely be compared with the archegonia and antheridia of the Bryophytes. These structures are to be related only with the greatest difficulty to the sexual organs of the algae, and probably not through any existing type of structure, unless it be the organ called the plurilocular sporangium.

There are several other groups of algae that confirm and illustrate in various particulars the principles of sexual evolution that we have traced in the three lines of development here described. The Siphonales duplicate the history in most of the stages. Isogamy with variation in the size of the gametes is found in several of the remaining groups. Heterogamy in its most extreme form is presented in such isolated types as the stoneworts (Charales), *Oedogonium, Bulbochaete* and *Sphaeroplea*. All these types stand as representatives of lines of extinct ancestry, whose sexual evolution must have passed through the stages that we have described.

The red algae (Rhodophyceae) do not enter into this discussion. They started with sexuality at an advanced stage of heterogamy.

Let us now briefly summarize with examples the steps in sexual evolution which we have discussed, beginning with isogamy, at the dawning of sex, and ending in heterogamy.

First Stage.—Isogamy with exactly similar gametes; the condition at the origin of sex. Exemplified by many of the lower algae, *Hydrodictyon, Ulothrix, Ulva, Cladophora,* etc., certain species of the lower brown algae and unicellular green.

Second Stage.—Isogamy with gametes similar in form but of different sizes, the female large and richly nourished, the male relatively small. Illustrated by species of *Chlamydomonas* and *Ectocarpus, Bryopsis* and the forms that also illustrate the third stage. An index to this condition is the differentiation of the gametangia with respect to the number of gametes developed. The female gametangium tends to reduce the number until a single egg takes all the material of the oogonium. The male gametangium increases the number of sexual products, becoming an antheridium that may develop numerous sperms.

Third Stage.—Isogamy in that peculiar form when the gametes are similar in form at the time of their discharge from the gametangia, but different at the time of fusion, because the female gamete becomes a motionless cell. Examples: *Ectocarpus siliculosus* and *secundus* and *Cutleria multifida.* This stage is the transition point between isogamy and heterogamy. Morphologically these gametes are isogamous; physiologically they are heterogamous.

Fourth Stage.—Heterogamy which has several grades in the degree of differentiation and specialization of the egg and sperm.

Fifth Stage.—The retention of the egg in the oogonium (female gametangium), a condition peculiar to but not at all universal among heterogamous higher algae. Illustrated by *Oedogonium, Bulbochaete, Coleochaete, Sphaeroplea, Chara* and *Vaucheria.* This stage would be developed quickly when once started, and a tendency in this direction is probably shown in *Aphanochaete.*

THE ECONOMIC IMPORTANCE OF FORESTRY.

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EXPERIMENT has already demonstrated the value of practical forestry as a sound business measure. The general application of conservative methods in the handling of public and private forest lands in this country is no longer a remote possibility. Ten years ago, the prevailing attitude towards forestry was one skeptical of its practical advantages. To-day the lumbermen, at one time the strongest opponents of the movement towards conservative forest management, are its staunchest advocates.

Although the application of practical forestry already exerts marked local influence, it is not yet sufficiently extended to form an important factor in our national economy. The time is not far distant, however, when its more general adoption will be felt in all industries dependent upon the forest. Forestry alone can perpetuate lumbering, and the fullest development of the mining industry rests largely upon it. Irrigation, and therefore agriculture upon irrigated lands, can be permanent only through forest preservation.

Mr. Henry Gannett gives the value of the products of the lumber industry for 1900 as about $567,000,000, and $611,000,000 as the invested capital. There were employed, exclusive of those working in dependent logging camps, about 400,000 persons, who received during the year a total of $140,000,000 in wages. Estimating conservatively, the lumber industry gave support in 1900 to 2,000,000 persons, while the number engaged in dependent trades, to whom it indirectly afforded a means of livelihood, was many times greater.

The geographical movement of the lumber industry is significant of a rapidly waning supply of merchantable timber. Fifty years ago, the northeastern states contributed more than one half the total lumber product of the country. They now furnish less than one sixth. In 1880 the Lake states produced one third of the supply, which has already sunk to about one fourth. In the southern and Pacific states, on the other hand, there has been a steady increase in production. These facts show that in the two geographical divisions nearest to the great centers of population, the available supply of timber is rapidly nearing exhaustion. The southern and the Pacific states, therefore, already yielding nearly forty per cent. of the total lumber product, will soon become the chief sources of supply.

In spite of steady improvement in tools, in machinery and in facilities for transportation, the increase in the value of logs and lumber becomes more and more rapid. The American lumberman has always been remarkable for enterprise and effectiveness, while American saw-mills compare favorably with those in any other country. These conditions, which would naturally tend to a sustained decrease in the cost of lumber products, are more than offset by the scarcity of available timber.

To sum up, the lumber industry of this country is approaching the end of its resources with alarming rapidity. It has, by over-production, fostered an abnormal demand, and by methods aimed at present profit alone, hampered the production of a second crop upon the lumbered area. Notwithstanding the growing economy in the harvesting, manufacture and distribution of forest products, their value is each year higher, while there is enormous increase in the importation of softwoods from Canada and of hardwoods from the tropics. Existing data as to the quantity of standing timber in the United States is insufficient for a close estimate of how long it will last at the current rate of consumption. It is inevitable, however, that the present generation will see the exhaustion of our first growth timber. Nor is the supply now standing so secure that it may be counted upon with certainty. Forest fires destroy annually timber aggregating over $50,000,000 in value, and measures to prevent them so far have not proved generally effective. It will be understood, moreover, that the crippling of the lumber trade and of all industries dependent upon it does not await the actual exhaustion of our forests. The geographical distribution of the great timber regions in this country, with relation to the chief sources of demand, is such that the local and not the total available supply is the urgent question. The fact that the heavy forests of the Pacific slope are sufficient to yield for many years an amount equal to the present annual consumption will not prevent a timber famine in the East, when to the price of the bulk of the wood it consumes is added the cost of transportation across the continent. Statistics giving comforting assurance of an abundant yield still at hand do not consider the effect upon wood industries of the substitution of timber of a few kinds only to fill a widely varying demand. The presence of hardwoods in the southern Appalachians and pine in the southern pine belt, in quantity sufficient to replace for some time the waning supply of spruce in the north woods, offers no substitute for the latter species in the manufacture of paper pulp. The redwood, red fir and hemlock of the Pacific coast will in some respects take the place of the longleaf pine, the exhaustion of which, at the present rate of consumption, will soon be accomplished. They can not, however, serve as the source of

naval stores, the production of which renders the longleaf pine the most important timber tree of the South. No general statements of large supplies of timber still available can disguise the gravity of the situation which now confronts the lumber industry. The solution of the problem can come only through a change in the policy and in the methods of the lumberman.

The history of lumbering in the United States has not differed essentially from that of the same industry in other countries. In the early days, the chief obstacle of the settler was the forest, while the growing need both of cleared land and of timber kept pace with the advance of colonization. The multiplication of demands for forest products developed feverish activity in the conversion of trees into money, while the methods employed in the harvesting of timber were the natural outcome of existing conditions. Forestry, with its perpetual but conservative returns, offered no financial inducement to the lumberman until the first crop of timber began to fail. With the forest stretched before him, large enough to feed his saw-mill for his lifetime, he had no need to consider the potential value of cut-over lands, often allowing them to revert in default of taxes to the state. His methods of lumbering were significant of his attitude. Skillful and effective in the cutting and transport of logs and the manufacture of lumber, he showed utter obliviousness to the productive capacity of the lumbered areas. Abuse of the lumberman is unmerited and unreasonable. His utilization of natural resources has been accomplished by mistakes similar to those incurred in the development of other industries in this country. The necessity for modification of his methods involves no emotional considerations. The question is one simply of the best business policy.

The attitude of the lumberman towards the source of his industry has so far been generally similar to that of the miner towards the gold mine. He has considered the value of the forest to lie only in the merchantable timber it contains, just as the mine is worthless when the end of the vein is reached. He has cut and burned with complete disregard of the welfare of immature trees, with the result that he has deprived the future of a supply of timber many times the value of the material he has actually utilized. There has been incalculable waste, which in some cases could have been avoided through slight expense, in others simply by the exercise of reasonable care, and which has hastened enormously the approaching exhaustion of the lumber supply. No one realizes more keenly than does the lumberman that the time for forestry has fully arrived.

The influence of the general adoption of practical forestry upon the lumber industry will be felt gradually, but it will eventually accom-

plish fundamental changes. It will substitute for an enterprise at present aimed only at the utilization of existing resources one embracing also measures for the production of its own supply. There will be steady and fair returns from lumbering, but spectacular opportunities for the investment of capital will cease to exist. The industry will assume normal proportions based upon the actual production of our forests, and will develop soundly with the increase in yield due to the improvement in conservative methods. A steady and sustained output, which may be estimated closely in advance, will tend to the maintenance of a constant scale of values, and to hamper speculation in logs or lumber. The size of the saw-mill will be regulated by the actual annual production of timber in the forest which supplies it. There will be a gradual elimination of enormous milling plants, and the general substitution of the saw-mill of medium size equipped for permanent use and under the same control as an area of forest land yielding a continued supply of timber equal to the capacity of the mill itself.

The general tendency towards wide distribution of the lumber industry will be an important economic feature of its development under conservative methods. The present movements towards centralization in the bodies of merchantable timber still remaining will cease with their consumption. In turning to second growth as a source of supply, the lumberman will establish himself wherever the productive capacity of cut-over lands under conservative handling offers him a fair return for his labor. The final result will be the development in each locality of a permanent class trained to forest work and a favorable geographical allotment of opportunities for the wage earner.

No man can foretell with certainty the value of timber produced under the application of practical forestry, nor the sustained supply which this country is capable of producing. The urgent necessity for the general adoption of conservative methods in lumbering does not rest upon the solution of these questions, but upon the established fact that the present value and the growing scarcity of timber render it profitable to foster the production of a second crop upon cut-over lands. It is to be remembered, also, that the results of forestry follow certainly but gradually. Its immediate adoption throughout the country would serve to shorten the period of decline which is the price the lumber industry must pay for phenomenal but unsound development, but the trees must have time to grow again. The new policy firmly established, the productive capacity of our forests fully utilized, it is believed—and the statement is amply sustained by the record of other countries with a proportionately smaller wooded area and a proportionately equal consumption of forest products—that neither will the value of timber

be excessive, nor its supply inadequate to meet the home demand. The establishment of lumbering as a sound and stable industry will be attained only when it reaps, as well as harvests, the crop upon which its existence depends.

Of the indirect returns from conservative forest management, the most valuable is its influence upon the flow of streams. The arid lands comprise two fifths of the area of the United States, and cover nearly all the western half of the continent. Their character varies with the amount of rainfall, ranging from true desert conditions to those capable of supporting a nomadic kind of grazing and a form of farming so low in its production that it promises little in inviting settlement. In his timely and forcible volume, 'Irrigation in the United States,' Mr. Newell states that the utilization of the vacant public lands can come about only through irrigation, or the artificial application of water to the soil, to supplement the scanty rainfall or to supply its absence. The area within the arid region which is irrigable is estimated at not less than 60,000,000 acres. The streams which may be diverted for purposes of irrigation rise in the forests, whose conservation is necessary to the maintenance of an abundant and sustained supply of water.

The passage of the Irrigation Bill, on March 1, 1902, paves the way for the adequate reclamation of the public lands. It sets aside receipts aggregating about $5,000,000 per year, received from the sale of lands within the arid region, and provides that they shall be applied to the construction of works for water conservation. The success of this great undertaking may be assured only through the preservation of the forests which feed the streams available for purposes of irrigation. The careful protection of these forests can be accomplished only by the federal government, through their management as national forest reserves. The exclusion from settlement of forest lands comprising the catchment basin of streams important for irrigation began under President Harrison, and has resulted in the creation of fifty reserves, with a total area of 53,107,685 acres, or 82,981 square miles. These are administered with a view to timber production only in so far as their more valuable function of water conservation is not affected. Their management is still hampered by its distribution among three branches of the government, and by difficulty in the rapid building up of a force of thoroughly trained and effective executive officers. There has, however, been progress in the prevention of timber theft and of fire, and the development of the fullest usefulness of the forest reserves is beset by no insurmountable difficulties. Their extension to include all large bodies of mountainous forest within or tributary to the arid region is essential to the fullest development of

the West. There is no more forcible statement of the dependence of irrigation upon forestry than the following extract from the first message of President Roosevelt to Congress:

> In the arid region, it is water, not land, which measures production. The western half of the United States would sustain a population greater than that of our whole country to-day, if the waters that now run to waste were saved and used for irrigation. The forest and water problems are perhaps the most vital internal questions of the United States.
>
> The forests are natural reservoirs. By restraining the floods and by replenishing them in drought, they make possible the use of water otherwise wasted. They prevent the soil from washing, and so protect the storage reservoirs from filling up with silt. Forest conservation is, therefore, an essential condition of water conservation.

Another function of the forest reserves, the regulation of which is at present the most urgent problem of their management, is the use of the grazing lands within their boundaries. Sheep and cattle raising are, and will continue to be, two of the great industries of the arid region. The over-grazing of lands important in the conservation of water supply is harmful in the dying out and hardening of the soil, as a result of the removal of its cover of herbs and grasses, and, in the case of over-grazing by sheep, in the destruction of seedlings and young trees. The purpose of forestry is not to impose unreasonable restrictions upon the development of the grazing industry within the reserves, but to regulate it with due reference to the interests both of the stockman and the irrigator.

The production of timber to fill the increasing needs of the mining industry is another great function of the national forest reserves. The laws governing their management confer upon the Secretary of the Interior power to designate, appraise and sell timber within them. The exercise of this provision under conservative measures can alone continue to permit an adequate supply of timber to the miner and for the home uses of settlers within the arid region.

Wood and water are the chief returns from forested areas. They produce the one and they conserve the other. So far, the treatment of our forests has tended only to impair their usefulness. Preservation without use is required neither of the private owner nor the federal government. Forest preservation by wise use alone can meet the national and the individual need.

MENTAL AND MORAL HEREDITY IN ROYALTY, VII.

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Evidence from the House of Nassau.

A. Elder Branch of Orange.

THIS branch of Nassau for five generations from William the Elder (1487–1559) to William, Prince of Orange, who became king of England (1650–1702), includes in the direct line 30 names. Completing the pedigree on the maternal side for each fraternity brings in 83 additional persons, and raises the entire group to 113.

The thirty in the direct line show remarkable characteristics and probably average, among the direct lines already discussed, more genius than all the rest of the countries put together, excepting that little region about Frederick the Great which we believe to have been formed from this. These illustrious names are William the Silent (10), Maurice (9), Frederick Henry (8), William II., Prince of Orange (8), William III., of England (9). These are father, two sons, grandson and great-grandson. If due to heredity, why was it perpetuated through four generations without reverting to the mean? This was largely due, as far as the second generation was concerned, to the fact that the stock was remarkably well maintained on the maternal side. Maurice had, for his mother's father, Maurice, the celebrated Elector of Saxony (9) and for a great-grandfather Philip Landgrave Hesse (7).

Frederick Henry was a grandson of Gaspard de Coligny, the great admiral of France (9), himself of distinguished stock, and the most remarkable member of the Montmorency-Coligny combination. Frederick Henry married Amelia of Sohns, a woman of fine character and high mental endowments; so it is not surprising that his son, William II., who died young, should have been a prince of exceedingly high promise.

In the next generation William II. married Mary, a daughter of Charles I. of England, so that the relatively poor blood of the Stuarts was introduced. He had but one child, William III., one of the greatest of England's kings. That the last of the line took from the paternal rather than the maternal side must be considered good luck, to say the least. Thus besides the remarkable unions we see also a selection inasmuch as the most highly gifted were sons, many

of the daughters showing the reversion to mediocrity and balancing up matters in the outside families into which they married, most of whom, if they left descendants at all, left only such as never rose above obscurity.

There were, however, among the other twenty-two grandchildren of William the Silent, three who were distinguished, one of whom, Turenne (10), ranks among the highest. The origin of the genius of William the Silent is not quite clear, since none of his ancestry in several degrees of remoteness were worthy of being called great, although they were of the sterling sort and above mediocrity. So William the Silent himself can not be taken as an instance of heredity, though all his descendants can. The moral tone was very high throughout, and corresponds either with the education or with the blood, since no bad characters were introduced, except Anne, second wife of William the Silent. She was violent, dissolute and finally insane. The later descendants are not from her. She had but two children and no legitimate grandchildren. Except that her daughter Amelia was extremely headstrong, her children appear to have escaped any influence from her.

Thus we see that the branch of Nassau is entirely confirmatory of the theory of heredity, and this should be taken into consideration in studying the causes of the rise of the Dutch Republic, since whatever was due to the personalities of these men finds its inner reason in the pedigrees which lie behind them.

The following is a list of all the grandchildren of William the Silent. This list analyzes the branch of Nassau in another way.

Those who are in (8), (9) or (10) are marked with an asterisk. To be in ranks (9) and (10) the persons must receive high praise in Lippincott's. Those in (8) may not always appear in Lippincott, but must at least receive very high adjectives in other authorities.

a. Children by Anne, daughter of Maximilian, Count of Buren:

1. Philip William.
2. Mary.

b. Children by Anne, daughter of Maurice, Elector of Saxony:

*3. Maurice of Nassau (9), 'one of the greatest captains of modern times.'
4. Anne.
5. Amelia = Emanuel of Portugal.

c. Children of Charlotte, daughter of Lewis, Duke of Montpensier:

6. Louisa Juliana = Palatine.
7. Isabella = de Bouillon.
8. Catherine = Hanau.
9. Flandria, a nun.
10. Charlotte = de la Tremoille.
11. Amelia = Palatine Deux-Ponts.
*12. Frederick Henry (8), celebrated stadtholder.

GRANDCHILDREN.

a. Children of Maurice of Nassau (illegitimate):

1. William Lord of Lecke, Vice-Admiral of Holland.
2. Lewis Lord of Lecke, Beverweed and Odyck, a general.

b. Children of Amelia of Portugal:

3. Mary Belgica.
4. Emanuel Felix of Portugal.
5. Amelia.
6. Anne.
7. Juliana Catherine.
8. Mauritia Eleonora.
9. Lewis of Portugal.

c. Children of Louisa Juliana:
10. Frederick V., Elector Palatine.
11. Elizabeth = Brandenburg.
12. Louisa Juliana = Palatine-Deux-Ponts.
13. Louis Philip = Palatine-Simmern.

d. Children of Isabella, Duchess de Bouillon:
14. Frederick Maurice, Lord of Sedan.
*15. Turenne (9), celebrated general.
16. Mary = Henry, Duke Tuars.
17. Juliana Catherine = Francis Count Roye.
18. Elizabeth = Marq. Duras.
19. Henrica Catherine = Goyau de la Moussaye.

e. Children of Catherine of Hanau:
*20. Amalia Elizabeth (9) = Hesse Cassel.
21. Philip Maurice, Count of Hanau.
22. Catherine Juliana.
23. Henry Lewis.
24. James John.

f. Children of Charlotte de la Tremoille:
25. Henry Duke Thonan Count Laval.
*26. Charlotte Countess Derby (9), a skilful commander and was 'the last person in the three kingdoms who submitted to the parliament.'

g. Children of Amelia = Palatine Deux-Ponts:
27. Frederick Louis, Count Palatine Landsberg.

h. Children of Frederick Henry:
28. Henrietta.
29. Mary.
30. Louisa.
31. Albertina.
*32. William II., Prince of Orange (8), a youth, of great promise.

Among the twelve children there were two distinguished. There were four distinguished grandchildren, but only four out of thirty-two, so we see a greater proportionate amount near to William the Silent himself; the greatest of the grandchildren, Turenne, occurs where he would most probably fall. He had a brilliant backing on both sides since his father was also 'a distinguished general.'*

B. Younger Branch of Nassau Dietz.

This other branch of the House of Nassau from which the present ruling family of Holland is descended may be well compared with that of Orange since for a number of years they lived and fought side by side in their struggles for liberty, and subsequent to their divergence took their blood largely from the same general sources that produced the geniuses already discussed. Although we find the brilliant branch of the family very largely represented in the pedigree as more remote ancestors, there was no such selection as would require heredity to place genius on the heads of any of the direct descendants.

This, together with the fact that none of the princes had large families of children, seems to sufficiently account for the observation that no great genius subsequently appeared in this branch.

The following is a list of the descendants in the direct line, their maternal pedigree having been looked up in each case, complete to all great-grandparents, and the distinguished ancestors are noted:

Children of John Sr. of Orange (no distinguished maternal ancestors):
1. William Louis, Stadtholder of Friesland—1620.
2. John Count of Siegen—1623.
3. Elizabeth—1611 = Nassau-Saarbruck.
4. Mary—1625 = John Louis Nassau Weisbaden.
5. Machtild—1625 = William Count Mansfeld.

* Lippincott's.

6. George, Count Nassau Dillenburg—1623.
7. Louis Gunther—1604.
8. Ernst Casimir—1558–1632.

Children of Ernst Casimir (no distinguished maternal ancestors):

9. Henry Casimir of Nassau Dietz—1640.
10. William Frederic, Count of Nassau Dietz—1664.

Children of William Frederick (had Henry Frederick (8) as grandparent and William The Silent (10) as great-grandparent):

11. Henry Casimir, Prince of Nassau Dietz—1657–1696.
12. Amelia.

Children of Henry Casimir (had Henry Frederick (8) as a great-grandparent):

13. John William Frizp—1687–1711.
14. Sophia Hedwig.
15. Isabella Charlotte.

Children of John William Frizp (had three distinguished great-grandparents, Henry Frederick (8) twice and Amelia of Hesse (9):

16. William, Prince of Nassau Dietz—1711–1757.
17. Anne Charlotte = Baden Durlach.

Children of William IV (had Caroline, Queen of England (8) as grandmother):

18. William V., Prince of Nassau—1748–1806.
19. Wilhelmina Carolina = Nassau-Wielburg.

Children of William V. (had Frederick the Great as great-uncle):

20. William I., King of the Netherlands.
21. William George Frederick—1774–1799.
22. Frederica Louisa = Brunswick.

Children of William I.:

23. William II., King of the Netherlands.
24. Frederick William Charles, Prince of the Netherlands—1792–1881.

Children of William II. (had Catherine II. as great-grandmother):

25. William III., King of the Netherlands.
26. Henry Prince of the Netherlands—1820.
27. Sophia = Saxe-Weimar.

Among the twenty-seven only three deserve the adjective brilliant. These are William I., king of the Netherlands, 'a captain, a hero, a legislator and a great man,'* and his younger brother, William George Frederick, who lived to be only twenty-five, but won considerable distinction and appears in the 'Biographie Universelle,' 'a rare model of all talents, virtues and precious qualities.' The third is the second son of William I., Frederick William Charles, who 'took a prominent part in the war of the Belgian revolution in 1830.'† These came together, and we suppose their talents came from the high wave about Frederick the Great.

Reviewing the list:

In the first two generations we get what we might well expect, since John Sr. of Orange, a brother of William the Silent, was, although an able man, in no way a genius.

In the third generation, we might not be surprised to see it reappearing, and heredity would demand it in a large number of children, but as there are only two, these may have taken after their parents who were obscure.

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* Alphonce Rablee in 'Biographie des Contemporaires.'

† Lippincott's.

The second generation after this is similar, so it seems to me there is nothing in the history of this house to speak against heredity, except that among the three children of William V., we find in two brothers a too large proportion of mental endowment, since there was no eminent relation nearer than great uncles and aunts. Thus about twenty-six of the twenty-seven give us the expected. This is another example of a royal house that did not degenerate through assumption of rank and power.

The moral tone remained good throughout and, although probably explicable on grounds of environment, is also in line with heredity.

Evidence from the House of Brunswick.

This family may be conveniently taken up next, since it is much like Saxe-Coburg in character, has intermarried with it and taken its tap-roots from much the same sources.

From Henry of Brunswick Danneburg (1546–1598) to William Duke of Brunswick Oels (1806–) we have eight generations with thirty-nine members of the direct house who are available for study. Of these thirty-nine all but Henry, above mentioned, and August (1579–1666) are given a full pedigree to the great-grandparent generation and studied with uncles and aunts as additional material. This brings into the group ninety-five more persons, or 144 in all. Among the thirty-nine we find one in grade (9), Amelia of Saxe Weimar, the distinguished patron of men of learning, and three in grade (8), William Adolphus, an author, and Charles William Frederick, the celebrated general in the Seven Years' War, and Juliana, the very ambitious and unprincipled queen of Frederick V., of Denmark. The gifted ones, Amelia of Saxe-Weimar, Charles William Ferdinand and William Adolphus, are niece and nephews of Frederick the Great and also of Juliana. The generation to which Juliana belongs also contains Ferdinand, a celebrated general, but his fraternity does not average quite as high as the next, which was formed by a union with the Hohenzollerns at the height of their greatness.

The first five generations of the House of Brunswick contain eight as high as grade (7), but none of these were distinguished sufficiently to be mentioned in Lippincott's. Only two, Ferdinand and his father, Ferdinand Albert II., were noted as generals.

The literary activity was very great, there being among the thirty-nine no less than ten who were authors. This authorship ran through five of the eight generations and should have appeared as it did, even setting aside the influence of education and example, since we find a remarkable breeding in of literary qualities somewhat comparable to what was found in the family of Saxe-Coburg-Gotha.

August (1579–1666), the second generation, married an authoress, Sophia Elizabeth; they had four children who were authors, among them Ferdinand Albert I. Ferdinand had several children, but no authors. One of these, Ferdinand Albert II., married Charlotte, not literary, whose father, uncle, aunt and grandfather were all authors. Among their nine children one, Elizabeth, published a number of translations and another, Ernst Ludwig, had literary taste and became the tutor of William of Orange.

The next generation is formed by the union with the literary Hohenzollerns and shows a fair proportion of authors, three in nine. After this none appeared. If these five generations of authors had accrued without any rejuvenation of blood, it would speak strongly for the effects of education. As it is, it could be used for an argument on either side. All that one can say is that heredity is satisfied. On the purely intellectual side there seems to be two rather serious deviations from Galton's law. The generation which contains the nieces and nephews of Frederick the Great is even more brilliant than would be expected. This may have been, as in the case of Frederick's own fraternity, either prepotency or superior opportunities of distinction, one can not tell which.

The next generation gives one of the worst results from the standpoint of heredity found anywhere, and we have quite the unexpected happening.

Two of the children, George William and Charles George, were mentally unfit to rule and consequently disinherited. In this connection it may be stated that a study of Denmark, Hesse Cassel and England has brought the author to the belief that this mental disease in the House of Brunswick was but a cropping out of the old Palatine insanity at the time of James I., of England. Christian VII., of Denmark, who was an uncontrolable imbecile and finally became mad, was a first cousin of George III., of England, who was insane during his later life, and Christian was also a first cousin once removed of the two little imbecile sons above mentioned, of Augusta, princess of Brunswick. Another more convincing bit of evidence in this connection is to be found in the neighboring House of Hesse Cassel. Here we find another who became insane and died in early manhood, and was a first cousin, once removed, of Christian VII. of Denmark. All these are related and only through the same source, the Palatine House, and since this Christian, of Hesse Cassel, is doubly descended from this suspected strain (Palatine House) it seems more than probable that we are dealing with an inherited insanity in all these cases. We may also mention Frederick William I., of Prussia, about whom Macaulay said: 'His eccentricities were such as had never been seen out of a mad house.' Frederick William was a first cousin of George

II., of England, and stands as near the actual Palatine insanity as a nephew.

These six cases would, if occurring in families of ordinary social grade, never make their way into asylum records as exhibiting a congenital tendency, since their close relations were not insane, but here, where we have the family tree and can look up the ancestry, curiously enough we find them all related and through the same source, Palatine, and this moreover the only one of their many lines of descent in which there was insanity. This is to be thought of when regarding the percentage which runs from twenty to 90 for heredity among the insane, according to the observer, and it should make us think that the higher rather than the lower figures are more likely to be correct.

This condition which caused the extinction of the House of Brunswick in the male line is often considered a common one in aristocracy, that is, a degeneration due to the assumption of rank and power, and consequent tendency to ease, dissipation and decline.

Jacobi has tried to show that the majority of royal and powerful families tend to end in degeneration and sterility. Degeneration without a corresponding pollution of blood, a contamination sufficient in itself to explain the condition I believe to be exceedingly rare, and I may say that there are no instances of such a degeneration among all the royal families that I have studied.

Among the 144 included in this group by reason of close relationship, there are two in (10), three in (9) and seven in (8). These are all centered about within two degrees of relationship of Charles William Ferdinand who was probably the most celebrated of any bearing the name of Brunswick. By making him the center of a group of forty-one, including only those more closely related to him, we find two in (10), three in (9), five in (8), eight in (7), that is $\frac{5}{40}$ of genius and of high talent. This is practically the same group of geniuses that centered about Frederick the Great in Prussia. It seems very probable on the grounds of heredity and entirely unlikely on any other.

THE SMITHSONIAN INSTITUTION.*

"THE advancement of the highest interests of national science and learning and the custody of objects of art and of the valuable results of scientific expeditions conducted by the United States have been committed to the Smithsonian Institution. In furtherance of its declared purpose—for the 'increase and diffusion of knowledge among men'—the congress has from time to time given it other important functions. Such trusts have been executed by the institution with notable fidelity. There should be no halt in the work of the institution, in accordance with the plans which its secretary has presented, for the preservation of the vanishing races of great North American animals in the National Zoological Park. The urgent needs of the National Museum are recommended to the favorable consideration of the congress." (President Roosevelt's first message to Congress.)

In the first Smithsonian report issued in the twentieth century it may not be amiss to tell the readers of this volume very briefly what the institution is, how it came into being, and how it has fulfilled the purposes for which it was established.

In the popular mind the Smithsonian Institution is a picturesque castellated building of brown stone, situated in a beautiful park at Washington, containing birds and shells and beasts and many other things, with another large adjacent building, often called the Smithsonian National Museum. The institution is likewise supposed to have a large corps of learned men, all of whom are called 'professors' (which they are not), whose time is spent in writing books and making experiments and answering all kinds of questions concerning the things in the heavens above, the earth beneath, and the waters under the earth.

Contrast this popular notion with the facts. The Smithsonian Institution is an 'establishment' created by an act of congress which owes its origin to the bequest of James Smithson, an Englishman, a scientific man, and at one time a vice-president of the Royal Society, who died in Genoa in 1829, leaving his entire estate to the United States of America 'to found at Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge among men.'

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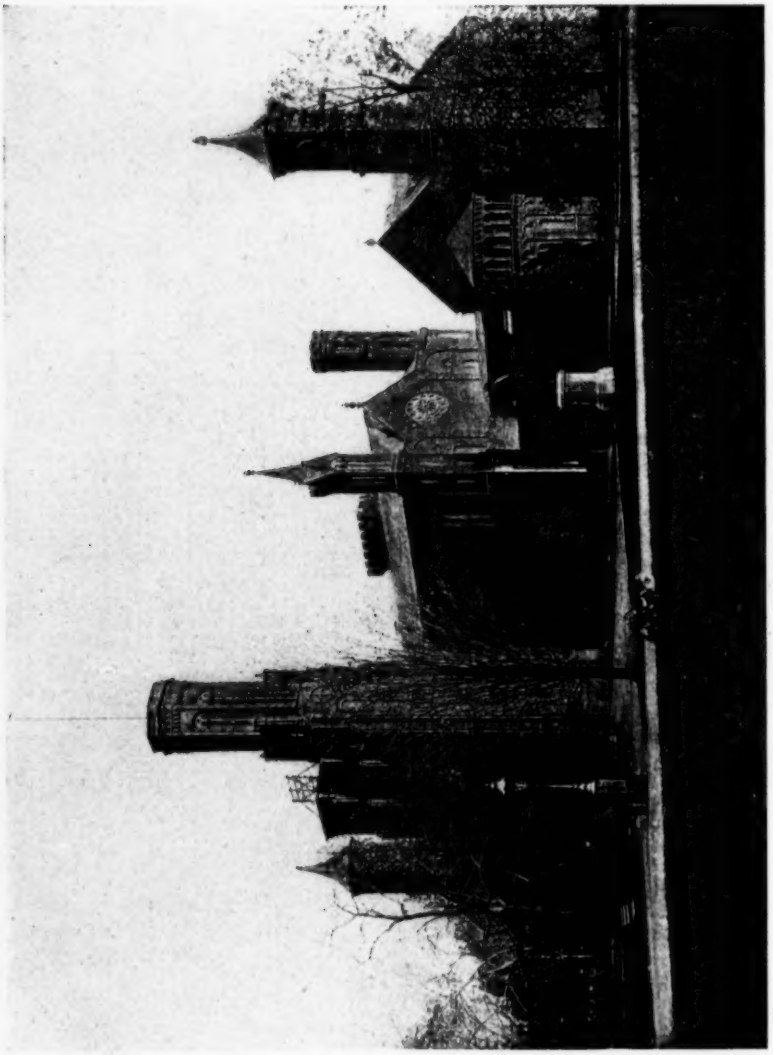
* This article is reprinted from the recent report of the Smithsonian Institution. We have pleasure in reproducing the official account of the foundation and activities of the institution, as we have had occasion to criticize its present management.

After ten years of debate in congress, turning partly on the question whether the government ought to accept such a bequest at all and put itself in the unprecedented position of the guardian of a ward, congress accepted the trust and created by enactment an 'establishment' called by the name of the Smithsonian Institution, consisting of the President of the United States, the Vice-President, the Chief Justice of the United States, and the members of the President's Cabinet. It has also a secretary, with varied functions, among others that of being the keeper of the museum.



THE SMITHSONIAN BUILDING.

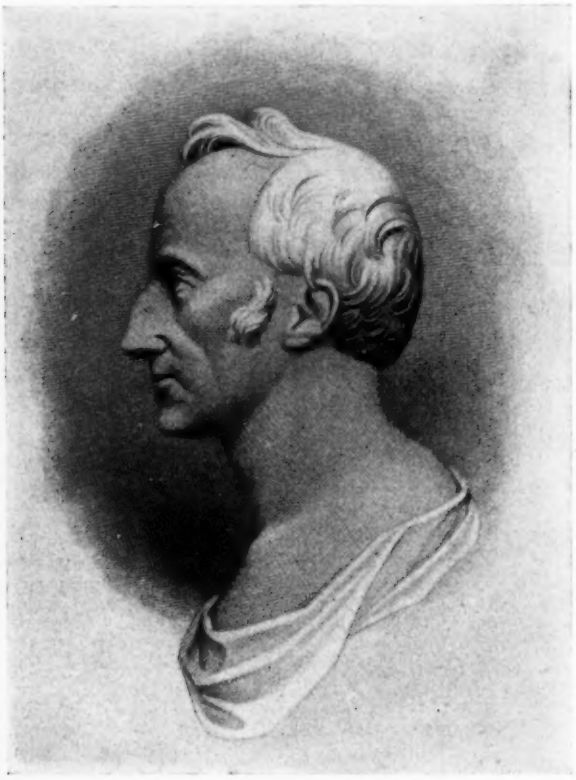
Smithson's money, which amounted to over half a million dollars, and later to three quarters of a million, a great fortune in that day of small things, was deposited in the United States Treasury, the government afterwards agreeing to pay perpetually six per cent. interest upon it.

In the fundamental act creating the institution, congress, as above stated, provided that the President and the members of his cabinet should be members of the institution, that is, should be the institution itself, but that nevertheless it should be governed by a board of regents, composed of the Vice-President and Chief Justice of the United States, three regents to be appointed by the president of the senate (ordinarily the vice-president), three by the speaker of the house of representatives, and six to be selected by congress; two of whom should be residents of the District of Columbia, and the other four from different states, no two being from the same state. The fundamental act further provides that the secretary of the institution already defined shall also be secretary of the board of regents. The museum is primarily to contain objects of art and of foreign and curious research; next, objects of natural history, plants, and geological and mineralogical specimens belonging to the United States. Provision is also made for a library, and the functions of the regents and of the secretary were defined.

The preamble of this bill states that congress has received the property of Smithson and provided 'for the faithful execution of said trust agreeable to the will of the liberal and enlightened donor.' It will thus be seen that the relations of the general government to the Smithsonian Institution are most extraordinary, one may even say unique, since the United States solemnly bound itself to the administration of a trust. Probably never before has any ward found so powerful a guardian.

The first meeting of the regents occurred on September 7, 1846, and in the autumn of the same year they elected as secretary Joseph Henry, then a professor at Princeton, known for his extraordinary experiments on the electromagnet, and other subjects relating to electricity. Under his guidance the institution took shape. Its work at first consisted, in the main, of the publication of original memoirs, containing actual contributions to knowledge, and their free distribution to important libraries throughout the world; to giving popular lectures in Washington, publishing them, and distributing them to libraries and individuals; stimulating scientific work by providing apparatus and by making grants of money to worthy investigators, cooperating with other government departments in the advancement of work useful to the general government, etc. These were the principal methods employed by Henry to carry out the purposes of Smithson, for the increase and diffusion of knowledge. Here, too, were initiated certain studies which

afterwards became most fruitful and have resulted in important government work, such as the present Weather Bureau, among others. The beginning of cooperation in library work was at this institution. At the same time many—we might almost say most—of the present scientific activities of the government have grown out of it or been stimulated by it. Experiments in fog signaling, in the acoustics and ventilation of public buildings, and in numerous other subjects, were inaugurated. In fact, in these earlier days, with one or two exceptions,



JAMES SMITHSON.

FOUNDER OF THE SMITHSONIAN INSTITUTION.

the Smithsonian was the sole representative of active scientific work directly or indirectly connected with the United States government. Its influence upon the character of private scientific work, too, was very great, since half a century or more ago the avenues for publishing were few, and the funds for the purpose slender.

Gradually, out of the collections which had been kept in the Patent Office, the private collections of Smithson, and of appropriations of

his money made by the regents, and largely also through the results of the great exploring expedition of Captain Wilkes, there grew up a Smithsonian Museum, one which was exclusively cared for from the Smithson fund; but which, partly through the greater activity of the government surveys and partly through the gifts of private individuals, and also through the valuable objects presented to the United States government by foreign nations at the close of the Centennial at Philadelphia in 1876, brought about the establishment of what is now known as the United States National Museum of the Smithsonian Institution, which is under control of the regents of the institution, for which a building was provided, and which now receives direct support from congress. This museum has now the matter belonging to the original institution collected by the Smithsonian's own observers, with much more secured through the general government, making in all over 5,000,000 specimens, and is the foremost collection in the world in everything that relates to the natural history, ethnology, geology, and paleontology of that portion of North America now the United States, besides containing many valuable series from other countries. The collections have been visited by over 7,500,000 persons, and the institution has carried selections of its specimens to every large exhibition held in the United States, and distributed 850,000 specimens to colleges and academies, thus powerfully stimulating the growth of museums large and small in every section of the country.

The publications of the Smithsonian have been in several series, mostly to convey to specialists the results of its original scientific investigations and to thus represent the first half of its fundamental purpose 'for the *increase* of knowledge,' and, subordinately, others to include handbooks and indexes useful to students, and some publications which, while still accurate, contain much information in a style to be understood by any intelligent reader, and thus represent the second half of the founder's purpose for the '*diffusion* of knowledge.' Many valuable publications, too, have been issued by the museum and the Bureau of Ethnology, and recently by the Astrophysical Observatory. In all, 265 volumes in over 2,000,000 copies and parts have been gratuitously distributed to institutions and private individuals, these works forming in themselves a scientific library in all branches.

Partly by purchase, but in the main by exchange for these publications, the institution has assembled a library of over 150,000 volumes, principally of serial publications and the transactions of learned societies, which is one of the notable collections of the world. The major portion of it has been since 1866 deposited in the Library of Congress, with which establishment the most cordial and mutually helpful relations subsist.

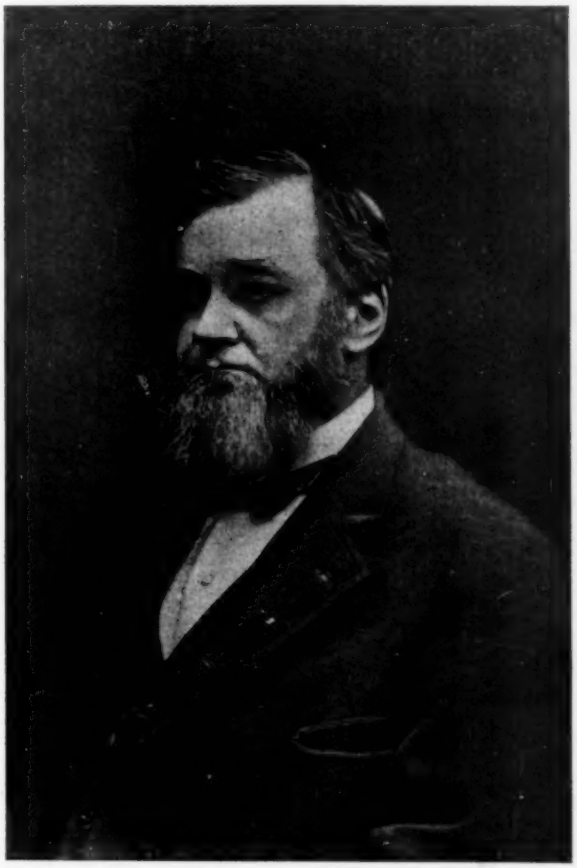
In 1850 Spencer Fullerton Baird, a distinguished naturalist, was elected assistant secretary of the institution. To him the great activity in natural history work was due, and by him the museum was fostered, he being greatly aided from 1875 by a young and enthusiastic naturalist, George Brown Goode. Secretary Baird initiated in the Smithsonian Institution those economic studies which led to the establishment of the United States Fish Commission.

JOSEPH HENRY.

FIRST SECRETARY OF THE SMITHSONIAN INSTITUTION, 1846-1878.

As another means of diffusing knowledge there was early established the bureau of international exchanges, originally intended simply for the proper distribution of the Smithsonian's publications, but which gradually assumed very wide proportions, becoming no less than an arrangement with learned societies throughout the world to reciprocally carry free publications of learned societies, or of individual scientific men, intended for gratuitous distribution. This system was after-

wards taken up by various governments which, through treaties, bound themselves to exchange their own publications in the same way. Since the inaguration of this service, 5,000,000 pounds weight of books and pamphlets have been carried to every portion of America and of the world. The institution existing not only for America, in which it has over 8,000 correspondents, but for the world, has throughout Europe,



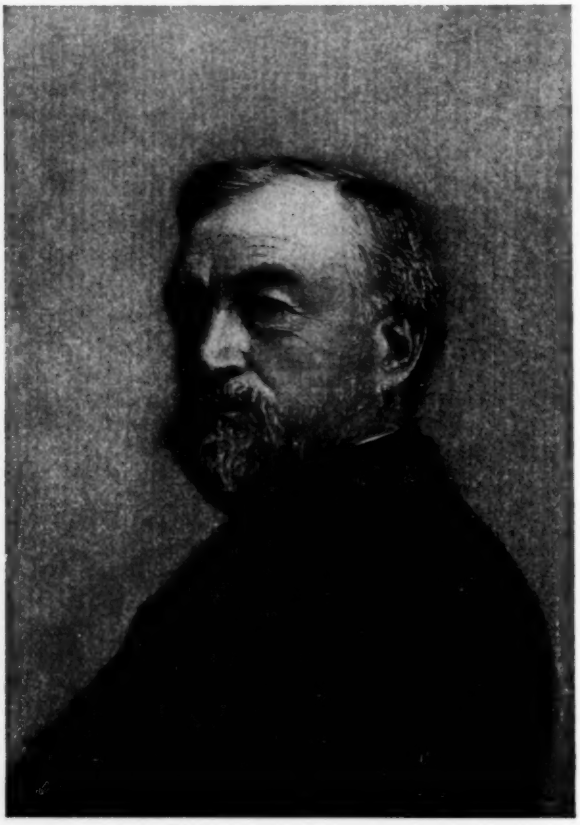
SPENCER FULLERTON BAIRD.

SECOND SECRETARY OF THE SMITHSONIAN INSTITUTION, 1878-1887.

Asia, Africa, and the islands of the sea, nearly 28,000 correspondents—more without the United States than within—justifying the words 'Per Orbem,' as the device on the Smithsonian seal.

Other work has been intrusted to the institution by the government, such as the Bureau of American Ethnology, for studies relating to the aborigines of this continent; the Astrophysical Observatory,

which for ten years has been chiefly devoted to the enlargement of Newton's work on the spectrum, and the National Zoological Park. The establishment of the latter was intended primarily to preserve the vanishing races of mammals on the North American continent; but it has also assumed the general features of a zoological park, affording the naturalist the opportunity to study the habits of animals at close range, the painter the possibility of delineating them, and giving pleasure and instruction to hundreds of thousands of the American people.



SAMUEL PIERPONT LANGLEY.

THIRD SECRETARY OF THE SMITHSONIAN INSTITUTION, ELECTED IN 1887.

These two latter establishments are due to the initiative of the present secretary, Mr. S. P. Langley, elected in 1887; a physicist and astronomer, known for his researches on the sun, and more recently for his work in aerodynamics. While the fund has been increased of later years by a number of gifts and bequests, the most notable being that of Mr. Thomas G. Hodgkins of a sum somewhat over $200,000, its

original capital, once relatively considerable, has now, in spite of these additions, grown relatively inconsiderable where there are now numerous universities having twenty times its private fund. It threatens now to be insufficient for the varied activities it has undertaken and is pursuing in every direction, among these the support of the higher knowledge by aiding investigators everywhere, which it does by providing apparatus for able investigators for their experiments, etc. Investigations in various countries have been stimulated by grants from the fund. It has been the past, as it is the present, policy of the institution to aid as freely as its means allowed, either by the grant of funds or the manufacture of special apparatus, novel investigations which have not always at the moment seemed of practical value to others, but which subsequently have in many instances justified its discrimination in their favor and have proved of great importance.

The growth of the institution has been great, but it has been more in activity than in mere bigness. The corner-stone was laid fifty years ago. In 1852 the entire staff, including even laborers, was twelve. In 1901 the institution and the bureaus under it employed sixty-four men of science and 277 other persons. These men of science in the institution represent very nearly all the general branches, and even the specialties to some extent of the natural and physical sciences, besides history and the learning of the ancients; and it may perhaps be said that the income of the institution (which, relatively to others, is not one tenth in 1901 what is was in 1851) has been forced to make good, by harder effort on the part of the few, what is done elsewhere in the government service by many.

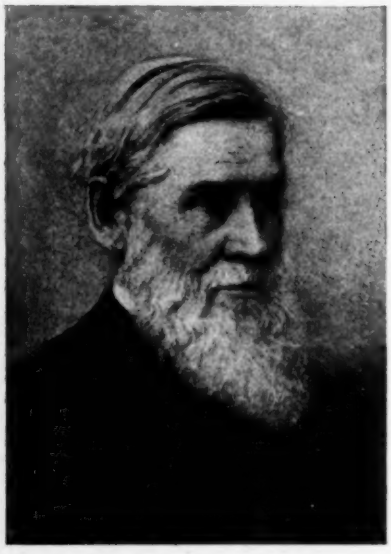
The private income of the Smithsonian Institution is not quite $60,000, but it controls the disbursement of about $500,000 per annum appropriated by the government for the bureaus under its charge.

Certain other functions difficult to describe are still of prime importance. The Smithsonian is called on by the government to advise in many matters of science, more especially when these have an international aspect. Its help and advice are sought by many thousands of persons every year, learned societies, college professors, journalists, and magazine editors, and thousands of private individuals, seeking information, which is furnished whenever it can be done without too serious a drain, though naturally a percentage of the requests is unreasonable. It has cooperated with scientific societies of national scope, like the American Historical Association, and has stimulated the growth of a number of the Washington scientific societies, and it may be said to teem with other activities.

The regents control the policy of the institution, and the secretary is their executive officer. Since the beginning the regents have been selected from among the most distinguished men in public life and

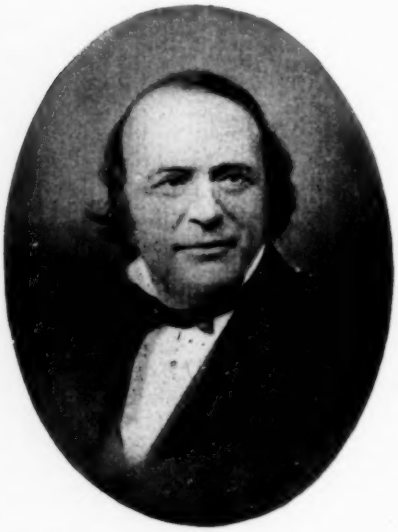
in the educational and scientific world. Their roll contains the names of the most distinguished American citizens for half a century.

GEORGE BROWN GOODE.
Assistant Secretary of the Smithsonian Institution, 1887-1896.



ASA GRAY.
Regent of the Smithsonian Institution, 1874-88.

An unwritten policy has grown up which, without instructions or regulations, has been of profound influence in the work. The Smithsonian Institution does not undertake work which any existing agency can or will do as well. It does not engage in controversies; it limits its work to observation and the diffusion of ascertained knowledge, not to speculation. It preserves an 'open mind' for all branches of knowledge and considers any phenomena which are the object of serious study within its purview. Its benefits are not confined to Washington nor to the United States, but as far as consistent are extended to all men.



LOUIS AGASSIZ.
Regent of the Smithsonian Institution, 1863-1873.

Its secretaries, assistant secretaries, and scientific officers have from the beginning—long before a classified service existed—been

elected and appointed for merit, and for that alone. No person has ever been appointed on the scientific staff for any political reason or consideration.

It is impossible to look into the future. The Smithsonian Institution has a remarkable organization for the administration of funds for the promotion of science; yet amidst the great benefactions of the past quarter of a century relatively few have come to it. Its activities could be still further increased if it had greater means under its control, and the regents, because of the peculiarly independent position they hold, can be of great public service in suggesting the channel into which gifts for scientific purposes might be directed, even if they do not see their way clear to accepting such donations for the institution itself.

For the National Museum a great new building is a prime necessity. The museum has practically reached a point where it is physically impossible that it should grow under present conditions.

Secretary Langley has for several years past been urging upon the government the dispatch of several expeditions for capturing the species of large mammals so rapidly being destroyed in the United States and Alaska; but even without this, the National Zoological Park, with its relationships to the other great national parks, is destined to be one of the great collections of the world.

The Bureau of American Ethnology, which since its organization has devoted itself to the aborigines of this continent, may have new work to do in Porto Rico and in Hawaii.

Among still other activities, of which there is now but a premonition, a National Gallery of Art (provided for by Congress in the original charter) may be alluded to.

The past of the Smithsonian Institution is secure, its present is known to all men, and it looks forward to the future in the belief that it will worthily continue under whatever changing conditions to 'increase and diffuse knowledge among men.'

RECENT JEWISH IMMIGRATION TO THE UNITED STATES.

By ROGER MITCHELL,
NEW YORK CITY.

FROM a stretch of territory of irregular breadth, and extending from the Baltic Sea to the Levant, there are now coming here in considerable numbers as immigrants a people of unmistakable identity of origin and differentiated from the other inhabitants of the districts whence they come not only by physical appearance, but by the possession of distinctive customs, traits of character and a language of their own. Even though the purity of their blood may be questioned, they stand as the modern representatives of one branch of the ancient Hebrew race. Their language is composite like English, and also like English it has a Germanic basis whose old inflections have been largely lost and to which words and suffixes of other origin, mainly Hebrew and Polish, have been added. This language is invariably expressed in Hebrew characters and read from right to left. Although occasionally efforts are made in certain quarters to disparage its claims to independent recognition, it is to be noted that it has served since ancient times as the medium of a literature, both meritorious and extensive, and is spoken whether in Riga or Constantinople with as little variation as may be found in the case of spoken English within the limits of the United States. In this language, solely by their own efforts, those who use it have lowered the illiteracy among the immigrant class to twenty per cent. while their Slavic neighbors, in spite of some public provision for instruction, show an illiteracy of about forty per cent.

All the people of whom Yiddish is the mother tongue are given special recognition in our Immigration Bureau's classification of arriving immigrants under the term 'Hebrews.' The people thus designated do not constitute the only branch of the Hebrew race in the region above mentioned, nor is Yiddish the mother-tongue of them all, but where the modern Hebrew fails to show this distinctive tongue and has become so merged with the nation in which he lives as to be indistinguishable except by pedigree or religious creed, he is classified with the immigrants of the nationality he has assumed.

By thus removing this one element of so distinctly a national character, not only is a means furnished for differentiating the other

national elements included within the same territorial limits, but there is also brought out in stronger relief a racial migration of essentially modern character, due to exceptional influences and one that will go down in history as among the most important in the annals of the Hebrew race.

Jews have been represented among the arrivals to this country since early colonial times. They appeared in considerable numbers as an accompaniment and sequel of our German immigration and were then derived largely from the German Polish provinces, but now the Jewish as well as the Polish immigration from these provinces has practically ceased. The Hungarian Jewish immigrant has likewise disappeared.

The immigration of the Yiddish-speaking Hebrew in the shape of an extensive exodus dates back scarcely twenty years, during which time probably not far from a million have come to this country from the Russian Empire, Galicia and Roumania, not as returning travelers or temporary sojourners, but for the most part as a new and permanent increment to our population.

An important factor in the causation of this movement is to be found in the acute phase which anti-Jewish feeling had assumed in eastern Europe twenty years ago. About 1880 widespread outbreaks of popular fury against the Jews were occurring in Russia. These disorders were followed by attempts on the part of the Russian government to enforce existing though neglected laws relative to the privileges of these people within the empire and to devise new measures for allaying popular clamor and complaint.

The unexaggerated accounts of the violence, robbery and brutality to which the Jews were being subjected by the Russian populace, the tenor of the Russian laws and the harshness with which they were enforced attracted foreign attention to the unfortunate condition of these people and opened to them a refuge in more western countries where the Jew had not been unfavorably known or where, by a similar violent process, he had been eliminated as an important economic factor centuries before.

Exceptional obstacles stood in the way of their emigration. Advance toward the east was forbidden by Russia and the police laws of the continental countries toward the west made a permanent refuge in this direction out of the question. The class to whom emigration would appeal lacked the resources for joining in distant colonial movements as the Germans and Scandinavians had done, and, unlike the Italians, Slovaks and Poles, these Jews were unprepared to supply the sort of labor for which a demand existed in other lands.

Foreign sympathy and organized charitable aid furnished the chief means of overcoming their inertia and starting the stream of migra-

tion to England and America. Prominently associated with the earlier aspect of this movement was a Jewish Colonization Association, which had at its disposal a fund of $50,000,000, a donation of the late Baron de Hirsch, but so far as the United States is concerned the new arrivals found in various vocations a sufficient degree of success to establish the immigration on a prepaid ticket basis on which it still continues.

The disabilities imposed upon the Jews in eastern Europe and the events associated with the Russian emigration are wont to be referred to as religious persecution. Tales of the use of the blood of christian children in religious rites and of stolen holy wafers punctured with a knife give a decidedly religious aspect to certain local outbreaks of violence. But the Russian church and the Russian people lack the proselyting spirit so characteristic of western people of whatever faith. While intolerant of dissenting sects from his own church 'because they invent their religions out of their own heads,' the Russian is inclined to respect the diverse religions of alien races as 'received from God.' Neither the Lutheran German nor the Mohammedan Tartar complains of religious persecution. In the case of the Jews, however, the matter of religious faith serves in Russia, Austria and Roumania as it has served in other lands to intensify a deep-seated feeling of popular resentment toward a race alien in speech and customs and closely identified with economic conditions that are commonly regarded as prejudicial to the common good; and it is not in the mere chronicle of clerical invective, political discrimination, violence and murder that the cause of this immigration and the explanation of its character are to be found, but in the economic history of a land where for centuries society was divisible into three classes, nobles, Jews and peasants.

Jews are known to have existed in Hungary and Roumania since Roman times, and within the present limits of Russia at a date almost as remote. But those emigrating to-day owe their presence there to much later migrations, both voluntary and involuntary, from more western Europe to Polish territory. Whenever the political condition of the western states of Medieval Europe became somewhat stable the expulsion of the Jews was almost sure to follow, and the refugees always tended eastward, finding more favorable conditions in those states whose political turmoil and continual squabbles gave little time for the consideration of internal affairs.

Poland offered such favorable conditions long after more western Europe had quieted down. Here the ancient Jewish element was obscured by continual Jewish immigration from the west, of which the wholesale migration from Bohemia near the close of the eleventh

century furnishes the first notable example. Later in the fourteenth century this movement was further stimulated by the historical privileges secured for the Jews through the influence of Esther of Opoeno, the Jewess favorite of Kasimir the Great. It is here also that the conception of the civil status of the Jew under Medieval Roman law received its fullest development, determining in a great measure the part which the Jew has played in the economic history of eastern Europe and still surviving as an important factor in the Jewish problem there to-day.

In the Germanic Roman Empire of the middle ages civil rights in a christian state were only for the orthodox Christian. An infidel or a heretic was an anomaly that was not supposed to exist. But, owing to their connection with the Roman empire and the relation of their faith to christianity, the Jews and the Jewish worship received special recognition and were tolerated within certain prescribed limits. In theory the Jews were regarded as being under the personal protection of the king, who accorded them their privileges by virtue of his being the legitimate successor and representative of the Emperor Titus.

In accordance with this status the Jews spread over the Polish kingdom as an alien nation, having a complete organization, a central authority, a system of jurisprudence and a language of their own, owing but a qualified allegiance to Poland and receiving their privileges and the laws determining their relations with the Polish people through bargains with the Polish king.

Moreover, as individuals they brought into eastern Europe, among a people not yet emerged from barbarism, intellects sharpened by centuries of mental training, habits and customs which had stood the test of two thousand years of civilization, and arts for which their race has been famous since the days of Jacob. Tales of their persecution, mingled with the clamoring and complaints of the Poles, are early in evidence. It is needless to undertake a recital of the results that have followed, for they have been no different from what might be imagined and, though superficially the story is one of racial prejudice and religious persecution, the underlying economic problem is always discernible.

In the meantime the Jews have shared the political vicissitudes of the Polish and Lithuanian kingdom, their ancient civil status has been modified, their former privileges abridged or readjusted and repeated attempts have been made to limit their opportunities for coming into competition with the thriftless slow-witted Slav; yet at the end of the nineteenth century we find the Russian government still claiming that the Jews prosper, like our trusts, to the detriment

of the country, and that also, like our trusts, they can not be made amenable to existing laws. An imperial circular directed to local officials after the disorders of 1882 reads as follows:

The proceedings at the trial of those charged with rioting and other evidences bear witness to the fact that the main cause of those movements and riots, to which the Russians as a nation are strangers, was but a commercial one, and is as follows:

During the last twenty years the Jews have gradually possessed themselves of not only every trade and business in all its branches, but also of a great part of the land by buying and farming it. With few exceptions they have as a body devoted their attention, not to enriching or benefiting the country, but to defrauding by their wiles its inhabitants, and particularly its poor people. This conduct of theirs has called forth protests on the part of the people, as manifested in acts of violence and robbery. The government, while, on the one hand doing its best to put down the disturbances and to deliver the Jews from oppression and slaughter, have also, on the other hand, thought it a matter of urgency and justice to adopt stringent measures in order to put an end to the oppression practised by the Jews and to free the country from their malpractices which were, as is shown, the cause of the agitation. With this in view, it has appointed a commission (in all towns inhabited by Jews) whose duty it is to inquire into the following matters:

I. What are the trades of the Jews injurious to the inhabitants of the place?

II. What makes it impracticable to put into force the former laws limiting the rights of the Jews in the matter of buying and farming land, the trade in intoxicants and usury?

III. How can these laws be altered so that they shall no longer be enabled to evade them, or what new laws are required to stop their pernicious conduct in business?

Give additional information on:

(*a*) Usury practised by Jews in their dealings.

(*b*) Number of public houses kept by Jews in their own names or in that of a Christian.

(*c*) Number of persons in service with Jews or under their control.

(*d*) The extent (acreage) of the land in their possession by buying or farming.

(*e*) Number of Jewish agriculturists.

Each line of inquiry directed therein had reference to some condition which had been a specific source of trouble. To take one instance which concerned the matter of land tenure, one of the most perplexing problems with which Russia, with its agricultural population, is called on to deal. The fondness of the Pole and Russian for drink served to make the liquor business particularly lucrative, and the Jewish liquor dealer utilized it as a means of involving the peasant in debt, and of finally securing from him the possession of his property rights; and where there was an annual assignment of communal lands the dealer with an eye to his own income saw that his best customers got the most productive parcels.

From old Poland the Jews spread north, east and south. In 1880 they were found to have penetrated the prohibited Russian territory to the east. In southern Russia they have added another failure to the efforts of their race to succeed as agriculturists. A considerable migration found its way to Roumania, and to a lesser extent to the Turkish empire. Since the western migration began numbers have gone into Palestine, though not always to remain, and the resources of the Baron de Hirsch fund have been used liberally in efforts to encourage and sustain a migration to South America, but to judge from the reports of the colonists who may be found coming to the United States by every South American ship, the movement has not yet proved a success.

The migration to Roumania went to increase an existing and practically Roumanized Jewish population of Spagnuoli and more ancient Hebrew stock and served to revive troubles that were believed to be past. At the bottom of the present anti-Jewish agitation in Roumania is an economic problem similar to that in Russia, likewise aggravated by a more or less improvident and shiftless indigenous population, but made still worse by the fact that the bearing of the Jew on the economic ills of the country has become a sort of political issue. Complicating the situation are also certain other elements entirely wanting in Russia.

Roumanian territory in the past has constituted a barrier to westward advance of the Mohammedan Turk, and the keynote of its history is resistance to racial religious aggression. As a dependency of Turkey the treaties and conventions which have determined its autonomy have repeatedly emphasized and affirmed a principle of religious inequality, the propriety of withholding full civil rights from a person of non-christian faith and of making a distinction between nationality and citizenship.

When, therefore, the powers in 1878 recognized the independence of Roumania, they overturned all local precedents in prescribing the principle of religious equality within the new kingdom. Subsequent events proved unfavorable to the popular reception of such a revolutionary idea. Stimulated by anti-Jewish agitation in adjoining foreign countries, an abnormal Jewish immigration poured into Roumania, and the alarm and resentment which this movement caused has been intensified by the new national spirit which independence has awakened among the Roumanians themselves.

Still regarded in accordance with old ideas as aliens whose rights were largely a matter for legislative action, the Jews have been deprived even of privileges which they formerly enjoyed, as have German settlers, Italian workmen, and other foreigners as well.

But to pass from the antecedents of our Jewish immigrants to the immigrants themselves. Except to some extent from portions of Austria and Roumania, they present little evidence of a state of prosperity that would be believed to be sufficient to excite the envy of the Slavic or Roumanian peasant. In general appearance and demeanor, as well as in the degree of their physical deterioration, they are in the main what might be expected from their civil status and immediate environment in the particular locality whence they come. But, in spite of an unprepossessing exterior and apparent contentment in squalid surroundings, the consciousness and pride of belonging to a superior race is always active and personal ambition is seldom extinct. They and their children have given abundant evidence of the qualities which have won distinction for their race in so many fields. Among them may be found the same active and well-balanced minds and the same tendency to concentration of energy for the accomplishment of the task on hand. They have a nervous make-up that is not easily susceptible to the formation of habits of body or thought, and it would often appear that their mental processes were not of the western order, but, after all, the Hebrew is only a more or less modified Oriental still.

So also they seem to possess to a high degree the power of divesting from the bias of prejudice or self-gratification the conclusions by which a course of action is governed, and to be less inclined than western people to be influenced by precedent or convention in making use of visible means for reaching a desired end. Like the southern Italians, they have a reputation for parsimony, but whereas the Italian in stinting himself and his family feels satisfaction in the thought that he has added an infinitesimal amount to the fund that will lead to the accomplishment of some indefinite future object, the Russian Jew only looks on the increments to his assets, like an athlete's medals, as evidence of contests that have been won and as an incentive, not to further efforts to save, but to increase his capacity to gain. To carry the contrast still further, the Hebrew immigrant in the most unaccustomed and bewildering surroundings never abandons his efforts to think for himself, and if compelled to rely upon guidance he will be as likely to repose a limited amount of confidence in a gentile stranger as in an unknown Jew. Instead of settling personal differences 'out of court' like the Italian, he is constantly in litigation, for he can not resist the temptation to utilize the obvious imperfections of our system of jurisprudence as a means of serving some personal end.

By far the majority of these immigrants have prospered. While still represented in the vocations with which they are commonly

associated in the public mind, and still exhibiting a predilection for commercial life, they or their children are also to be found in nearly every trade and profession, and are coming into increasing prominence in connection with those positions in the public service which are open to competitive examinations.

This immigration has also another side. The fact that it has been stimulated by pressure from behind rather than a demand in the industrial market here has tended not only to make it possible for the movement to override or evade our immigration laws but also to get beyond the control of the philanthropic organizations which have the best interests of the immigrants at heart.

The tendency of Hebrews to prosper diminishes as they congregate together, and, quite apart from the matter of civil disabilities, there is a proportion above which they are unable to thrive in any given city or town. These conditions have already been realized in certain localities here, and philanthropic effort which was once concerned principally in inducing emigration from unfavorable surroundings in Europe is now attempting to prevent and relieve the equally serious evils of congestion in localities to which it is tending. With reference to the situation in New York city the 27th Annual Report of the United Hebrew Charities (October, 1901) makes the statement 'that a condition of chronic poverty is developing in the Jewish community of New York that is appalling in its immensity.' It goes on to state that, of the applicants to that society for assistance during the year, 45 per cent., 'representing between 20,000 and 25,000 human beings, have been in the United States over five years; have been given the opportunities for economic and industrial improvement which this country affords, yet notwithstanding all this, have not managed to reach a position of economic independence.' It, furthermore, makes the estimate that 'from 75,000 to 100,000 members of the New York Jewish community are unable to supply themselves with the immediate necessaries of life, and who for this reason are dependent, in some form or other, upon the public purse.'

To a degree wholly unlooked for among Jews, the above-mentioned phase of the present Hebrew immigration is accompanied by a moral degradation which has, to some extent, been made familiar through recent events in local municipal politics.

As the report of the society above referred to stated in 1898, 'those who are familiar with the crowded section on the lower east side know that vices are beginning to spring up which heretofore have been strangers to the Jewish people.' Referring to the same conditions, it is asserted in the report for 1901 that 'the vice and crime, the irreligiousness, lack of self-restraint, indifference to social conventions,

indulgence in the most degraded and perverted appetites are growing daily more pronounced and more offensive.'

There would seem to be a disposition to regard such moral deterioration as the result of the prevalent squalor and overcrowding, but it is to be noted that the conditions in which these people live in New York at the present day are superior to those to which most of the immigrants were accustomed before they came, and are much better than those which they find in our other large cities or in London. The squalor and overcrowding, though conspicuous because of the extent of the 'Ghetto,' is much less pronounced than in the Italian, Syrian or Greek quarters, and the household régime of the poorest Jews gains by comparison with the family life of other foreigners in the tenement districts.

Moral deterioration may be pointed out in the case of every foreign element that has come to this country, just as it may be among the country-bred youth of our own population who feel in new abodes loss of personal identity and exemption from former moral restraints. In the case of foreigners there is added also a loss of parental control through the greater facility with which children identify themselves with the language and customs of the new environment and by what passes for the process of 'becoming Americanized,' the younger Jews come to look with indifference and even contempt upon the precepts which have safeguarded their race through a troublous past.

After all, when it is considered that the Jews have been estimated as constituting one fourth of the population of Manhattan, it may be questioned whether evidence of moral degradation may not have attracted attention because it was unexpected rather than because it is unproportionally prevalent.

In a great measure the poverty to be found in the 'Ghetto' is due to disease or lack of physical strength. Jewish immigrants of a military age who could pass our army requirements for recruits are comparatively rare, while few of their fellow immigrants, the Poles, would fail to pass such a test. Among the Jews also, senile decay is pronounced at an age when the German, Englishman or Scandinavian is still in his physical and mental prime. Chronic disease is much more prevalent among the Hebrew than among the Slavic immigrants, and common among the former are diseases rarely if ever seen in the case of the latter. The mental standard of the Jewish immigration fails to offset its physical inferiority when brought into active competition with other elements of our cosmopolitan population. Physical breakdown comes sooner or later and the ravages of tuberculosis are in evidence to an extent that is quite at variance with old notions of racial insusceptibility to this disease. This state of

affairs is further aggravated by the favorable expectation of life for the Jew, something quite distinct from the matter of health or capacity for work. Temperate habits and the religious factor in the conduct of ordinary matters of diet and life, as well as their absence from hazardous occupations, contribute to this result. An apparent longevity also results from the fact that infant mortality among them is exceedingly low. The centuries through which these people have been associated with the worst phases of civilized life have undoubtedly led to an inherited ability on the part of the children to exist in unfavorable surroundings and an increased power of resistance to certain diseases, but it is also to be noted that in the humblest Jewish household the first symptoms of acute illness will not be overlooked nor neglected, and that the sick child will receive the best available professional attention, together with such a degree of unremitting care and attention on the part of the family, as can seldom be realized among Gentiles of the same station in life.

THE BEHAVIOUR OF BLIND ANIMALS.

By Professor WESLEY MILLS, M.A., M.D.,
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IN the course of years I have had the opportunity of observing a considerable number of animals totally blind in either one or both eyes and to these only shall I refer in this paper.

Pigeons.—All those observed, that were otherwise normal, have been blind on one side only. The defect does not seem to have resulted in any great inconvenience or disadvantage to the individual. Birds do not, it is likely, possess binocular vision, in the sense in which the term may be applied to many mammals; and in consequence of the defect, cutting off the field of vision on one side completely, the bird endeavors to make up for this by adaptive movements of the head, which it can bring about with a facility not possible to the mammal.

It also, through experience, becomes more alert than the average pigeon; nevertheless, when the struggle for existence becomes keen, as for example when a limited quantity of food is strewn about, it is shown to be plainly at a disadvantage, both in securing the food and in the bodily conflicts that are apt to arise between it and its competitors.

White Rats.—I have observed several white rats, some of which were blind in only one eye, others in both. The results were in some respects very different from what might have been expected, and in this the difference between the bird and the rabbit, on the one hand, and the rat, on the other, was striking.

Even in the case of total blindness, the rat is not handicapped as one might suppose must be the case. In a very few days the rat blind in only one eye seems to ordinary observation to be in no appreciable degree worse off than his fellows. In a short time the specimen, totally blind, moves about so well that one would need to look carefully to be assured that he gets no assistance from the visual sense. But in his case there are times when it is evident that he is handicapped. In exploring new surroundings he proceeds with special caution, stretching out his neck, sometimes resting on his hind legs, more frequently elevating his fore parts and sniffing in an unusual way, showing an extreme care and plainly making use of his acquired greater facility, or perhaps one should say, his accustomed and habitual greater use of senses that normally are not required to function to such a marked degree.

He is also somewhat more timid and retreats in the way rats do toward their place of exit, with greater readiness. He is of course more

at the mercy of his enemies, and yet not to the degree one might have supposed on account of his greater caution as well as the fact that his senses of touch and smell make up so fully for the lack of sight. It must be borne in mind that the olfactory tracts of the central nervous system in the rat are highly developed and their association-paths numerous, so that in an eminent degree the rodent, and especially the rat, is worked, so to speak, as an entire mechanism largely through the reflex paths of smell.

One of the unexpected results of sudden blindness in the case of white rats, whether affecting one or both eyes, was a most marked alteration in disposition. Rats that were perfectly tame became at once ferocious; it was unsafe any longer to attempt to handle them as formerly, or to remove anything from their cage, for in an instant they seemed aware of the approach of one's hand and were not only ready but able to pounce upon it at once; even metal forceps were seized by the teeth. After a considerable period in a rat blind in both eyes this ferocity disappeared, but not so, or to but a slight extent, in those lacking the power of vision on only one side.

In our experience in the breeding of white rats, it is rare for the female to devour her young, but invariably have those blind white rats killed and eaten to a greater or less extent every litter they have had, though placed under circumstances exactly similar to those of the intact rats.

Rabbits.—My opportunities to observe this species of rodent when blindness was found on one or both sides, has been almost as good as in the case of the rat. The differences noted in the animals is considerable. A rabbit totally blind behaves in general much like a rat similarly defective, but he shows less tendency on occasion to retreat towards his place of safety, is less alert and apparently less prepared to meet emergencies. But the readiness with which he manages to avoid obstacles in his path is striking. He also, like the rat, stretches out his neck, rises sometimes on his hind legs, but more frequently raises the fore parts of his body into the air, all with the obvious purpose of exploring the nature of his environment to a degree and with a frequency not witnessed in the normal rabbit. Such an animal is, however, more likely to fall under the power of his enemies than is the rat, though so long as food is plenty near his burrow the wild animal would no doubt develop that caution and use his other senses to such an extent that he would generally escape; but that he would in the long run fall a prey to some wily fox seems more than probable.

I have noticed no change in disposition in the case of the rabbit akin to that in the rat and none of the blind specimens has had young.

Neither the rabbits nor the rats ever make the mistake of walking off a place elevated above *terra firma*. As I have elsewhere pointed out,

this tendency seems to be a fundamental instinct manifested by even the youngest mammals and is evidently of vital importance for their preservation.

Cat.—The cat on which I am able to report was not in good condition after she became suddenly blind in both eyes, and lived but a few days, or I should have been able to note more fully whether her psychic state had been modified by experience.

When put down on the floor she moved about in a slow and apparently cautious way, and, though plainly perfectly blind, when she came near objects she touched them only slightly. In this the whiskers evidently served a good purpose, as was also observed in the rodents. When one made a noise on the floor as by tramping with the feet, puss invariably moved towards the sound, and so perfectly that by walking about one could cause her to describe complicated figures, from which and other observations I conclude that she had become a mere reflex mechanism worked by the most prominent stimuli of the moment from the external world. When she came to a wall, and especially a corner, she stopped and sometimes lay down—showing that the 'puss in the corner' tendency has a deep foundation, for I am inclined to believe that this animal was not conscious in the true sense of the term. This cat had become blind owing to a hemorrhage into the optic thalamus of the brain and lived but a few days afterwards.

I have not reported any other cases in this paper in which there were brain lesions, the discussion being too complicated for my present purpose. That the cat was guided purely reflexly by sounds was evident from the fact that when one stood on a table and tramped as before, puss underneath the table was soon brought to a standstill just below the source of the sounds. Such a remarkable case of guidance reflexly by the ear I had not seen before, and it proved very instructive to me.

Dog.—Of the blind dogs I have observed I shall refer to but one. He was a cross-bred skye terrier and formed one of a litter kept in a room in the college basement. He became totally blind when between two and three months old. After this he soon changed greatly in disposition; he, like the rats, seemed to revert to a sort of feral condition. He would on the entrance of any one into the room hide, and when approached would bite savagely at the extended hand; in fact, in order to catch him it was necessary to throw a sack or some such object over him. He had gnawed away the legs on which his cage stood and to which he was chained for a time.

This dog seemed to be at least equal in intelligence to the other members of the litter, his companions. So far as the objects in the room that had a stable situation were concerned, he was perfectly oriented, but if a new object was laid down he would run against it and

then attack it as savagely as he would one of his fellows who came in his way.

If any stranger came to the door of the room he seemed to know instantly and would bark fiercely, but he never did this when the regular attendant entered, however silently he approached, being guided probably largely, but by no means wholly, by the sense of smell. He was by far more alert than any of his companions and seemed to be put into a state of high tension by the slightest stimulus.

This dog had a ravenous appetite, and when the vessel containing food for all the dogs of this litter was put down he was generally the first to reach it, though at the moment he might possibly be in the most distant part of the room, and certainly he did not come off second best in the struggle.

He was so like a wild animal, was of so bad a temper, and altogether so undesirable a creature, I thought it best to chloroform him at the end of a few weeks.

PREVENTIVE MEDICINE.*

By General GEORGE M. STERNBERG, U.S.A.

FROM the earliest times physicians have taken the lead in all that relates to the prevention of disease. In times of epidemic their advice is sought by afflicted communities and they have been instrumental in securing most of the legislation which has been enacted with a view to preventing or restricting the prevalence of infectious diseases. As members of boards of health, they are largely responsible for the enactment and execution of proper sanitary legislation, and as medical officers of the Army and Navy, they are charged with the duty of guarding the health of soldiers and sailors enlisted in the service of their country.

While the principal function of a physician engaged in civil practice is to give proper advice and treatment to the sick, he is constantly called upon to point out the most effectual methods of preventing the extension of infectious diseases in the homes of his patients; to indicate the proper diet and mode of life to be followed by convalescents and other members of families which he regularly attends, etc. All this he does cheerfully, although he rarely receives any compensation for advice of this kind and his professional income is diminished in direct proportion to his success in the prevention of disease among the families constituting his clientele.

The compensation for voluntary work in public or domestic sanitation is to be found in the consciousness of good accomplished and of high and humane motives worthy of the profession to which we belong, and the willingness to perform such voluntary service is one of the most noteworthy distinctions between the educated and honorable physician and the ignorant and mercenary quacks who prey upon the community with no other object in view than that of gain. The beneficent results of preventive medicine are seen in the greatly reduced mortality rates in civilized countries generally, and especially in the fact that certain pestilential maladies which formerly prevailed as wide-spread and devastating epidemics, causing the death of hundreds of thousands of human beings annually, have to a great extent lost their deadly potency as a result of the progress of our knowledge with reference to their etiology and the best methods of combating them.

* Address introductory to the course in preventive medicine, given on January 12, 1903, at the opening of the Washington Post-graduate Medical School.

Smallpox no longer claims its victims in any considerable numbers except in communities where vaccination is neglected; cholera has been excluded from our country during the last two widespread epidemics in Europe and its ravages have been greatly restricted in all civilized countries into which it has been introduced; the deadly plague of the seventeenth and eighteenth centuries is no longer known in Europe and the prevalence of typhus—so-called spotted or 'ship fever'—has been greatly limited. Typhoid fever, tuberculosis and diphtheria are still with us and claim many victims, but we know the specific cause of each of these diseases; we know where to find the bacteria that cause them and the channels by which they gain access to the human body; and we know how to destroy them by disinfecting agents.

The mortality from tuberculosis is constantly diminishing in our large cities and the complete destruction of the infectious sputa of those suffering from pulmonary tuberculosis would no doubt go a long way towards the extermination of this fatal disease.

Perhaps the triumphs of preventive medicine can not be better illustrated than by a brief historical account of the prevalence of bubonic plague during the past three or four centuries. It can scarcely be doubted that the 'black death' of the fourteenth century was the same disease which subsequently prevailed in Europe under the name of 'the plague'—now more generally spoken of as 'bubonic plague.' While modern methods of diagnosis have enabled us to recognize typhoid fever, typhus fever, relapsing fever and bubonic plague as distinct diseases, it must be remembered that up to the end of the fifteenth century no such differentiation had been made and the term 'pest' was applied to any fatal malady which prevailed as an epidemic, and no doubt in some instances included smallpox, which prior to the discovery of Jenner contributed largely to the general mortality of the population of Europe.

Bubonic plague continued to prevail in various parts of Europe at the end of the sixteenth century, and early in the seventeenth century (1603) an epidemic occurred in London which caused the death of 38,000 of its inhabitants. It continued to prevail in this city and in various parts of England, Holland and Germany and six years later caused a mortality of 11,785 in the city of London. During the year 1603 a most disastrous epidemic occurred in Egypt, which is said to have caused a mortality of at least a million. After an interval of ten or fifteen years, during which there was a marked diminution in the number of cases and the extent of its distribution in European countries, it again obtained wide prevalence during the year 1620 and subsequently, especially in Germany, Holland and England. The epidemic in the city of London in 1625 caused a mortality of more than 35,000. In 1630 a severe epidemic occurred in Milan, and in 1636 London

again suffered a mortality of over 10,000, while the disease continued to claim numerous victims in other parts of England and on the continent. Later in the century (1656) some of the Italian cities suffered devastating epidemics. The mortality in the city of Naples was in the neighborhood of 300,000, in Genoa 60,000, in Rome 14,000. The smaller mortality in the last-named city has been ascribed to the sanitary measures instituted by Cardinal Gastaldi. Up to this time prayers, processionals, the firing of cannons, etc., had been the chief reliance for the arrest of pestilence, with what success is shown by the brief historical review thus far presented. But this enlightened prelate inaugurated a method of combating the plague and other infectious maladies which, with increasing knowledge and experience in the use of scientific preventive measures, has given us the mastery of these pestilential diseases, and has been the principal factor in the extinction of bubonic plague from the civilized countries of Europe.

But it was long after the time of Cardinal Gastaldi before sanitary science was established upon a scientific basis and had acquired the confidence of the educated classes. Indeed, the golden age of preventive medicine has but recently had its dawn, and sanitarians at the present day often encounter great difficulty in convincing legislators and the public generally of the importance of the measures which have been proved to be adequate, when properly carried out, for the prevention of this and other infectious maladies.

We have now arrived in our review at the period of the 'great plague of London.' For some years this city had been almost if not entirely free from the scourge, but in the spring of 1665 it again appeared and within a few months caused a mortality of 68,596 in a population estimated at 460,000. This, however, does not fairly represent the percentage of mortality among those exposed, for a large proportion of the population flew from the city to escape infection.

Upon the continent the disease prevailed extensively, especially in Austria, Hungary and Germany. The epidemic in Vienna in 1679 caused a mortality of 76,000. In 1681 the city of Prague lost 83,000 of its inhabitants. During the last quarter of this century the disease disappeared from some of the principal countries of Europe. According to Hirsch it disappeared from England in 1679, from France in 1668, from Holland about the same time, from Germany in 1683 and from Spain in 1681. In Italy it continued to prevail to some extent until the end of the century.

At the beginning of the eighteenth century bubonic plague prevailed in Constantinople and at various points along the Danube; from here it extended in 1704 to Poland, and soon after to Silesia, Lithuania, Germany and the Scandinavian countries. The mortality in Stockholm

was about 40,000. The disease also extended westward from Constantinople through Austria and Bohemia.

In 1720 Marseilles suffered a severe epidemic, probably as a result of the introduction of cases on a ship from Leghorn. The mortality was estimated as being between 40,000 and 60,000. From Marseilles as a center it spread through the province of Provence, but did not invade other parts of France. In 1743 a severe outbreak occurred on the island of Sicily. A destructive but brief epidemic, which is estimated to have caused a mortality of 300,000, occurred during the years 1770 and 1771 in Moldavia, Wallachia, Transylvania, Hungary and Poland. At the same time the disease prevailed in Russia, and in 1771 caused the death of about one fourth of the population of the city of Moscow.

Early in the nineteenth century (1802) bubonic plague appeared at Constantinople and in Armenia. It had previously prevailed in the Caucasus, from which province it extended into Russia. In 1808 to 1813 it extended from Constantinople to Odessa, to Smyrna and to various localities in Transylvania. It also prevailed about the same time in Bosnia and Dalmatia. In 1812 to 1814 it prevailed in Egypt, and, as usual, was conveyed from there to European countries. During the same year it prevailed extensively in Moldavia, Wallachia, and Bessarabia. In 1831 it again prevailed as an epidemic in Constantinople and various parts of Roumelia, and again it appeared in Dalmatia in 1840 and in Constantinople in 1841. Egypt, which for centuries had been the principal focus from which plague had been introduced into Europe, continued to suffer from the disease until 1845 when it disappeared from that country.

The last appearance of oriental plague in Europe, until its recent introduction into Portugal, was the outbreak on the banks of the Volga in 1878–79. The disease had previously prevailed in a mild form in the vicinity of Astrakhan and was probably introduced from that locality. An interesting fact in connection with this epidemic is that in Astrakhan the disease was so mild that no deaths occurred, and that the earlier cases on the right bank of the Volga were of the same mild form, but that the disease there increased rapidly in severity and soon became so malignant that scarcely any of those attacked recovered. This is to some extent the history of epidemics elsewhere, and not only of plague, but of other infectious diseases, such as typhus fever, cholera and yellow fever. In all of these diseases the outset of an epidemic may be characterized by cases so mild in character that they are not recognized, and during the progress of the epidemic many such cases may continue to occur. These cases are evidently especially dangerous as regards the propagation of the disease, for when they are not recognized no restrictions are placed upon the infected individuals, although they may be sowing the germs broadcast.

The termination of an epidemic in the pre-sanitary period depended to a considerable extent upon the fact that those who suffered a mild attack acquired thereby an immunity; and that when the more susceptible individuals in a community had succumbed to the prevailing disease there was a necessary termination of the epidemic for want of material.

Another factor which no doubt has an important bearing upon the termination of epidemics is a change in the virulence of the germ as a result of various natural agencies. Time will not permit me to discuss this subject in its scientific and practical aspects, but the general fact may be stated that all known disease germs may vary greatly in their pathogenic virulence, and that in every infectious disease mild cases may occur, not only because of the slight susceptibility of the individual, but also because of the 'attenuated' virulence of the specific germ. In the eighteenth century, the beginning of sanitary science, isolation of the sick and seaboard quarantines came to the aid of these natural agencies, and did much in the way of arresting the progress of this pestilential disease. At the present day these measures, together with disinfection by heat or chemical agents, are relied upon by sanitarians with great confidence as being entirely adequate for the exclusion of this disease or for stamping it out if it should effect a lodgment in localities where an enlightened public sentiment permits the thorough execution of these preventive measures; but when the disease prevails among an ignorant population which strenuously objects to the carrying out of these measures, the contest between the sanitary officer and the deadly germ is an unequal one, and the stamping out of an epidemic becomes a task of great magnitude, if not entirely hopeless. This is illustrated by the experience of the English in their encounter with bubonic plague in their Indian Empire.

Plague seemed to be almost a thing of the past and no longer gave any uneasiness in the countries of Europe which had formerly suffered from its ravages, when in February, 1894, it made its appearance in the city of Canton, China, and three months later in Hong Kong. The disease is known to have been epidemic in the province of Yunnan, which is about 900 miles distant from Canton, since the year 1873, but it attracted little attention until the lives of Europeans living in the city of Hong Kong were threatened by the outbreak of an epidemic among the Chinese residents of that place. Many thousands of deaths occurred in Canton during the three months which elapsed after its introduction to that city before it effected a lodgment in Hong Kong.

Fortunately this outbreak gave the opportunity for competent bacteriologists to make scientific investigations relating to the specific cause of this scourge of the human race and to the demonstration that it is due to a minute bacillus. This discovery was first made by the

Japanese bacteriologist, Kitasato, who had received his training in the laboratory of the famous Professor Robert Koch, of Berlin. This discovery was made in the month of June, 1894, in one of the hospitals established by the English officials in Hong Kong. About the same time the discovery was made, independently, by the French bacteriologist, Yersin. From this time the study of the plague has been established upon a scientific basis and very material additions have been made to our knowledge with reference to the prevention and treatment of the disease.

That the plague bacillus has not lost any of its original virulence is amply demonstrated by the high death-rate among those attacked, and we are justified in ascribing its restricted prevalence to the general improvement in sanitary conditions in civilized countries and to the well-directed efforts of public health officers in the various localities to which it has been introduced during recent years. In the Philippine Islands, where it prevailed to a considerable extent when our troops first took possession of the City of Manila and where the conditions among the natives are extremely favorable for its extension, it has been kept within reasonable bounds and, indeed, the latest reports indicate that it has been practically exterminated by the persistent efforts of the medical officers of our army, charged with the duty of protecting the public health in those Islands.

The monthly report of the Board of Health for the city of Manila for September, 1902, the last at hand, records but one death from plague during that month. During the same period there were ten deaths from typhoid fever, thirty-five deaths from dysentery and seventy-six deaths from 'the great white plague,' pulmonary tuberculosis.

Bubonic plague, cholera and typhoid fever have long been classed as 'filth diseases,' and in a certain sense this is correct, although we now know that the germs of these diseases not only are not generated by filth, but do not multiply in accumulations of filth. They are present, however, in the alvine discharges of the sick, and when this kind of filth is exposed in the vicinity of human habitations or gains access to wells or streams, the water of which is used for drinking, the germs are likely to be conveyed to the alimentary canals of susceptible individuals, and thus the disease is propagated. Until quite recently the attention of sanitarians was so firmly fixed upon the demonstrated transmission of cholera and typhoid fever through the agency of contaminated water or milk that certain other modes of transmission were overlooked, or at least underrated. I refer to the transmission by insects, or as dust by currents of air. I have for many years insisted upon the part played by flies as carriers of infectious material from moist masses of excreta from cases of cholera and typhoid fever. There

is good reason to believe that the bacillus of bubonic plague may be transmitted in the same way. The cholera spirillum is quickly killed by desiccation and this disease is probably very rarely, if ever, communicated through the medium of dust. But the germs of typhoid fever and of bubonic plague are more resistant and, without doubt, under certain circumstances, these diseases are extensively propagated by means of dust containing desiccated excreta. There is a good reason to believe that in several of our camps, during the Spanish-American War, this was an important factor in the etiology of typhoid fever epidemics. The average mortality from typhoid fever in our regular army since the Civil War has been, for the first decade (1868–1877) 95 per 100,000 of mean strength; for the second decade (1878–1887) 108 per 100,000, for the third decade (1888–97) 55 per 100,000. This latter rate compares favorably with that of many of our principal cities; for example, it is exceeded by the typhoid death-rate of the city of Washington, which is 78.1 per 100,000 (average of 10 years, 1888–1897), by that of the city of Chicago, which is 64.4 per 100,000; by that of Pittsburgh, which is 88 per 100,000. As a result of insanitary conditions existing in the camps in which our troops were hastily assembled at the outset of the Spanish-American War, the typhoid death-rate in our army of volunteers and regulars during the year ending April 30, 1899, was more than 22 times as great as it had been in our regular army during the decade immediately preceding the war period. As compared with the Civil War, however, there was a decided improvement, the typhoid mortality for the first year of the Civil War having been 1,971 per 100,000 of mean strength and for the Spanish-American War 1,237 per 100,000.

Experience shows that new levies of troops are especially subject to typhoid fever and other infectious 'camp diseases,' not only because of lack of discipline and consequent difficulty in the enforcement of sanitary regulations, but also because the individual soldiers are very susceptible to infection, owing to their age, the abrupt change in their mode of life, the exposure and fatigue incident to camp life, and last, but not least, their own imprudence as regards eating, drinking, exercise, etc. In the absence of sewers or other adequate means of removing excreta, the camp site is likely to become infected by the discharges of unrecognized cases of typhoid and typhoid bacilli are carried by flies to the kitchens and mess-tents and deposited upon food, or as dust are directly deposited upon the mucous membranes of the respiratory passages of those living in the infected camp. That preventive medicine has still serious work before it is shown by the fact that according to the last census return there were 35,379 deaths from typhoid fever in the United States during the census year 1900. The increase in mortality over the number in 1890 (27,056) is out of proportion to the

increase in population, notwithstanding the general improvement in the sanitary condition of towns and cities. This is no doubt due to the continued pollution of water supplies and to the extension of this infectious disease in rural districts. It is in fact now an endemic disease in nearly all parts of the United States.

According to the census report of 1900, there were 111,000 deaths from tuberculosis during the year 1900. This does not, however, include the deaths in certain states in which the vital statistics are incomplete or unreliable, and it is probable that there are at least 145,000 victims of the great white plague annually within the limits of the United States. The last census return in those states where registration was approximately correct, including a population of about 21,000,000 people, shows that 12 per cent. of all deaths resulted from pulmonary tuberculosis, 8.5 per cent. from pneumonia, 3 per cent. from typhoid fever and 3 per cent. from diphtheria and croup. These figures indicate to some extent the task which preventive medicine has still to accomplish.

A most interesting and notable example of the beneficent results following the practical application of sanitary measures based upon exact knowledge relating to the etiology of an infectious disease is afforded by the recent extinction of yellow fever in the city of Havana, which for many years had been the principal focus of infection in the West Indies, and the port from which it has been repeatedly carried to the seaport cities of the United States. According to the reports of the health officers in that city, there has not been a case of yellow fever in Havana for more than a year, and the extinction of the disease is ascribed entirely to the vigorous measures enforced to prevent its transmission by mosquitoes of the species proved by the researches of Reed and Carroll to be the immediate hosts of the yellow fever parasite and the active agents in the transmission of the disease from man to man. During the first sixty years of the past century, yellow fever prevailed almost annually in one or more of the southern seaports of the United States and not infrequently it extended its ravages to the interior towns in one or more of the southern states. So frequently did it prevail during the summer months in New Orleans and Charleston that the permanent residents of those cities commonly regarded it as a disease of the climate and a necessary evil which it was folly to attempt to combat by quarantine restrictions.

In the great epidemic of 1853, yellow fever prevailed extensively in the states of Florida, Alabama, Louisiana, Mississippi, Arkansas and Texas. The epidemic of 1867 was limited to the states of Louisiana and Texas. Those states again suffered severely in 1873 and the states of Florida, Alabama and Mississippi were also invaded. A still more extended and deadly epidemic occurred in 1878, causing a mortality

of 15,934 out of a total number of cases exceeding 74,000. In this epidemic the disease followed the Mississippi River to the very suburbs of St. Louis, and the state of Tennessee suffered severely as well as the states south of it. The city of Memphis alone had a mortality from the disease of about 5,000. These repeated epidemics not only cost the lives of thousands of citizens and paralyzed business of all kinds during their prevalence, but apprehension with reference to the recurrence of the disease very materially interfered with the growth of many southern cities and retarded greatly the development of those portions of the country most liable to invasion. All this is now changed; public health officials are no longer filled with apprehension upon the approach of summer by the thought that any ship arriving from Havana may introduce the deadly pestilence to our shores; commerce is no longer subjected to the serious restrictions formerly considered necessary for the exclusion of the disease; and the public generally have been made aware that the fangs of this threatening monster have been drawn by the scientific demonstration of its mode of attack and the simple measures which have been proved to be effective in preventing its propagation. Until the recent demonstration of the transmission of yellow fever by mosquitoes, this disease was generally regarded as one of the filth diseases, although there were many facts opposed to this view. In the light of our present knowledge we can no longer class it with typhoid fever, cholera, bubonic plague and dysentery, in which diseases the germ is known to be present in the alvine discharges of the sick and which are, consequently, well named filth diseases.

We now see clearly, however, why in certain particulars relating to its etiology it resembles the malarial fevers. It is limited as regards its prevalence to comparatively warm latitudes or to the summer months in more temperate regions and is dependent, to a certain extent, upon rainfall or the proximity of standing water, because these conditions are necessary for the propagation of mosquitoes. As regards the filth diseases, properly so-called, no single agency is more important for their prevention than the use of properly constructed sewers for the reception of excreta and its removal from the vicinity of human habitations. Sewers had come into use and had the warm endorsement of sanitarians long before the discovery of the germs of the infectious maladies under discussion, and before it was positively known that the infectious agent in these diseases is contained in the discharges from the bowels. But now that we have an exact knowledge of the etiology of these diseases, the reason for the beneficent results attending the use of sewers, in connection with an ample and pure water supply, is apparent. It may be safely asserted that a city or town having a complete and satisfactory sewer system and a pure water supply is practically immune from epidemics of cholera or typhoid

fever, provided, of course, that the sewers are used for the purpose for which they are intended, and that streets and back yards no longer serve as receptacles for filth, as was usual during the presanitary period even in great cities like London and Paris. The axiom 'tout a l'égout' now governs the practice not only in Paris, but wherever the fundamental principles of municipal sanitation are understood and sewers have been constructed. Unfortunately, the cost of sewer construction, the reluctance of tax-payers to part with their money and the ignorance or indifference of municipal authorities have conspired to prevent the accomplishment of this fundamental sanitary measure in very many towns in the United States, and our endemic plague—typhoid fever—continues to claim a large annual quota of victims in such localities. Even in the national capital our sewer system is incomplete and in many out-of-the-way places, especially in the densely populated alleys of the city, shallow box privies are in use as receptacles for human excreta and the typhoid fever rate, owing to this and other causes, is disgracefully high.

Mortality rates in towns and cities throughout the civilized world depend to a large extent upon the purity of the water-supply and the efficiency of the system of sewage disposal; and the constant improvement which is shown by the mortality statistics of England and other countries which have made the most progress in this direction is undoubtedly largely due to these two factors. This is well illustrated by the mortality statistics of armies. In the German army the annual death-rate in 1868 was 6.9 per thousand, a decade later it was 4.82, in 1888 it had fallen to 3.24 and in 1896 to 2.6. In our own army, the death-rate during the period of peace just prior to the Mexican War (1848) was about three and one half times as great as during the five years preceding our recent war with Spain, and since the year 1872 there has been a diminution of the death-rate of nearly forty per cent. In the British army at home stations the mortality rate during the decade ending in 1884 was 7.2 per thousand, in 1889 the rate had fallen to 4.57 and in 1897 to 3.42. In the Italian army there has been a gradual and progressive reduction from 13.3 per thousand in 1875 to 4.2 in 1897. The mortality in the French army was a little over 21 per thousand during the five years ending in 1825. In 1890 it had fallen to 5.81 per thousand.

According to the best estimates the average of human life in the sixteenth century was somewhat less than twenty years. At the present time it is more than twice as long and during the past twenty-five years the average duration of life has been lengthened about six years. During the first thirty-five years of the past century the vital statistics of the city of London showed a mortality of about 29 per thousand. At the present time the mortality in that great city has been reduced to from

17 to 19 per thousand. I will not burden you with further statistics, but will simply say that even more notable results have been obtained in many parts of the civilized world as a result of increased knowledge and improved methods for the prevention of infectious diseases and the general improvement in hygienic conditions.

The time at my disposal only permits of a brief general survey of the field which comes within the purview of the department of preventive medicine of the Washington Post-Graduate Medical School. It will be our aim during the course to give detailed information and practical laboratory instruction upon all the more important subjects connected with this branch of medicine. This will be apparent to those who have read our 'circular of information' with reference to the course of instruction. This includes personal and municipal hygiene, a practical knowledge of sanitary chemistry, including food adulterations and pathogenic bacteria, of animal parasites injurious to man, of preventive inoculations, of disinfection, of military and naval hygiene, of national and international quarantine, etc. Fortunately we have among our professors, experts upon all of these subjects and we believe that the city of Washington offers unequaled facilities for a comprehensive and scientific course of instruction in preventive medicine. Such a course as would seem best fitting for preparing graduates in medicine for the responsible duties of health officers in the towns and cities throughout the United States, and as is essential for medical officers in the various branches of the public service. But, while we have many special advantages for giving a comprehensive and practical course in the department of preventive medicine, it must not be thought that clinical medicine and surgery are to be neglected. On the contrary, we have ample advantages for clinical instruction in the various hospitals of the city and a corps of competent and experienced professors who are prepared to give practical instruction in all branches of medicine and surgery. Those physicians who enroll themselves as students in the Washington Post-Graduate Medical School and faithfully follow the course of instruction which is open to them, can not fail to return to their professional work with broader and more exact information on many subjects relating to scientific medicine, with increased skill in the diagnosis and treatment of disease and with greater confidence in the resources of the noble profession to which they have devoted their lives.

A STATISTICAL STUDY OF EMINENT MEN.

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THE accounts of great men in biographies and histories belong to literature rather than to science. Modern science is either genetic or quantitative. It seeks to discover those uniformities which we call causes and to use that method of description which we call measurement. It is now time that great men should be studied as part of social evolution and by the methods of exact and statistical science.

History is only the last chapter of organic evolution, and both where similar causes are at work and where new factors have arisen, the parallel between social and organic evolution is instructive. While the Darwinian principle of natural selection as an explanation of the origin of species has an aspect which makes it almost as naïve as the doctrine of special creations, it has given an extraordinary stimulus to modern thought. Natural selection is no cause of the origin of species or of anything else, but the environment is the condition of the survival of species and of individuals. Evolution has progressed through the occurrence of variations sanctioned by the environment. We are, it is true, not only ignorant of the causes of variations, but even of their nature. We do not know whether one species has been derived from another by gradual variations in many individuals or by sudden jumps in a few. We do not know whether the type prescribes the individual, or whether the individual forms the type. Yet in spite of our ignorance not only of the causes but even of the nature of organic evolution the distinctions formulated by the naturalist are fruitful when applied to social evolution.

It is evident that there are two leading factors in producing a man and making him what he is—one the endowment given at birth, the other the environment into which he comes. The main lines are certainly laid down by heredity—a man is born a man and not an ape. A savage brought up in cultivated society will not only retain his dark skin, but is likely to have also the incoherent mind of his race. On the other hand, environment has at least an absolute veto. Had the infant Newton been cast among Hottentots he could have announced no laws of motion. But were those differences—small from the point of view of organism, great from the point of view of function—which distinguished Dante from his Florentine fellow townsmen innate or due to the circumstances of his life? Here the biological parallel may be

serviceable. Are those variations which produce new species caused by the environment? Can life be regarded as the resultant of physical forces? Many zoologists and physiologists answer in the affirmative, but it appears rather that life develops not on account of, but in large measure in spite of, physical forces—these tend to the dissipation of energy, they are the causes of death rather than of life. So in like manner it seems that the environment would tend to reduce the great man to its level rather than to lift him above it—Dante wrote in spite of his surroundings, not on account of them. Still the environment counts for much. If the seed of the white pine is dropped among New England rocks it will grow into a small bush, if planted in the rich soil of the south it will become a great tree. We have the 'Divine Comedy' because Dante had 'the steep stairs and bitter bread' in place of Beatrice.

As the environment tends to reduce all things to its level, so heredity tends to maintain the type. Whence then the great man who brings something new into the world? Carlyle had the same heredity and the same initial environment as his brothers. Why should he write of heroes and become one, while they remained peasants? Why, we may ask the theory of organic evolution, should certain individuals of a species possess variations tending to greater complexity, which lay down the lines of evolution? Perhaps all we can say is that the question 'why' is more in place in the nursery than in the laboratory. Why heredity should maintain the type is as obscure as why new types should arise. If the world were a chaos, no questions would be asked, as it is a cosmos it must have a certain definite order. But if when we ask 'why' we really mean 'how,' then we have the plain way of science before us. We can investigate the stability and variability of the type, we can study the effects of the environment on the individual. We know perhaps in a general way that any great war will find the material at hand for the making of a Grant and a Lee, and, on the other hand, that a Shelley may be what he is in spite of heredity and environment. More exact knowledge can only come from an inductive study of facts.

As in organic evolution the effects of variations are less obscure than their causes, so in social evolution we can trace more easily the influence of great men than we can account for their origin. As we ascend the scale of animal life and human development the rôle of social tradition becomes increasingly potent. A new trait in a single individual among lower animals, even though it may be both useful and stable, can have but an infinitesimal effect in altering the species. In man a new advance made by a single individual becomes quickly the common property of all. Let fire be discovered and we have a trait that endows every one. Let the printing press be invented and each can speak with a thousand tongues. Let Dante see the ideal of

romantic love and every boy and girl in Christendom has his life altered thereby. What we now are—as men—depends chiefly on social tradition; withhold it for a generation and we should revert to savagery and further. It is also true that social tradition sets the course of organic development. Individuals who are unfit for their social environment can not survive in it; those who possess variations, however slight, making adjustment to social conditions and social ideals more easy are more likely to survive and to transmit their traits. If we depended only on social tradition, progress would be limited by the extreme range of individual adaptations. But by the preservation of stable variations in the line of social evolution, we secure a new type from which new forward variations are more likely.

Whether great men really lay down the line of social evolution or only anticipate and hasten its necessary course is an unsolved question. Are great men, as Carlyle maintains, divinely inspired leaders, or are they, as Spencer tells us, necessary products of given physical and social conditions? If Dante had not set the ideal of romantic love, would it not have come from other sources? Did Darwin do more than express what was 'in the air' and hasten by a dozen years the necessary course of science? We can only answer such questions by an actual study of facts.

When we regard the noteworthy men that have appeared in the world, it is evident that they have but little in common. 'Some are born great, some achieve greatness, and some have greatness thrust upon them.' We have men of genius, great men and men merely eminent. Thus many a genius has been a 'mute inglorious Milton' lacking the character or the circumstance for the accomplishment of his task. Washington was scarcely a genius, but was a truly great man. Napoleon III. was neither a genius nor a great man, but was eminent to an unusual degree. But if we simply take those men who have most attracted the eyes and ears of the world, who have most set its tongues and printing presses in motion, we have a definite group. Beginning with this we can analyse and classify; we can study these individuals, their causes and their effects; we can regard them as types of a given age and race; we can use them to measure interests and tendencies.

For these purposes our first need is a definite list of the most eminent men, sufficiently large for statistical study.* The method I followed to discover the 1,000 men who are preeminent was this: I

* The statistics of this paper were presented to the American Psychological Association in December, 1894, and an abstract was published in *The Psychological Review* for March, 1895. It was read in its present form as a lecture before the Philosophical Club of Yale University in 1897.

took six biographical dictionaries or encyclopædias*—two English, two French, one German and one American and found the two thousand men (approximately) in each who were allowed the longest articles. In this way some 6,000 men were found. I then selected the men who appeared in the lists of at least three of the dictionaries, and from these (some 1,600) selected the thousand who were allowed the greatest average space, the value of the separate dictionaries being reduced to a common standard. Thus was obtained not only the thousand men esteemed the most eminent, but also the order in which they stand.

This list represents the point of view of these dictionaries, and would be somewhat different had other works been selected. Mathematical science can indeed assign a probable error to each name on the list, and tell us how likely it is that the man should be there, and within what limits his place on the list is likely to be correct. But the greater men of the thousand would remain whatever the authorities collated; and although the personal names of the lesser men might vary, this would affect but little the statistics sought. The preparation of this list required more work than may be supposed, but it has an objective impartiality and value, which it would not have if the names had been selected by an easier method.

According to this list the ten most eminent men are Napoleon, Shakespeare, Mahommed, Voltaire, Bacon, Aristotle, Goethe, Cæsar, Luther, Plato. There is no doubt but that Napoleon is the most eminent man who has lived. Yet it should give us pause to think that this Titan of anarchy stands first in the thoughts of most men. It is curious that these ten preeminent men are so widely separated in race and age —two Greeks, two Frenchmen, two Germans, two Englishmen, one Roman and one Arab: two in the fifth century and one in the first century before Christ, one in the sixth, one in the fifteenth, two in the sixteenth and three in the eighteenth century. The ten names last on the list are Otho, Sertorius, Macpherson, Claudian, Domitian, Bugeaud, Charles I. of Naples, Fauriel, Enfantin and Babeuf. These are scarcely great men, yet they fairly represent the lower limits of the thousand who are most eminent. Each hundred in the list shows a nice gradation in eminence. There are indeed many cases where each of us would shift a man up or down, but further examination will show that the opinion in such cases is usually individual, not having the objective validity of this series. I give for reference the thousand preeminent men of the world in the order of eminence, divided into groups of one hundred.

* 'Lippincott's Biographical Dictionary,' 'The Encyclopædia Britannica,' Rose's 'Biographical Dictionary,' 'Le dictionnaire de biographie générale,' Beaujean's 'Dictionnaire biographique' and Brockhaus's 'Conversationslexicon.' There is no biographical dictionary in German nor any encyclopedia as satisfactory as the Britannica, neither do such works exist in Italian, Dutch or Scandinavian, otherwise it would have been desirable to have used them.

Napoleon, Shakespeare, Mohammed, Voltaire, Bacon, Aristotle, Goethe, Julius Cæsar, Luther, Plato, Napoleon III., Burke, Homer, Newton, Cicero, Milton, Alexander the Great, Pitt, Washington, Augustus, Wellington, Raphael, Descartes, Columbus, Confucius, Penn, Scott, Michelangelo, Socrates, Byron, Cromwell, Gautama, Kant, Leibnitz, Locke, Demosthenes, *Mary Stuart*, Calvin, Molière, Lincoln, Louis Philippe, Dante, Rousseau, Nero, Franklin, Galileo, Johnson, Robespierre, Frederick the Great, Aurelius, Hegel, Petrarch, Horace, Charles V. (Germany), Mirabeau, Erasmus, Virgil, Hume, Guizot, Gibbon, Pascal, Bossuet, Hobbes, Swift, Thiers, Louis XIV., Wordsworth, Louis XVI., Nelson, Henry VIII., Addison, Thucydides, Fox, Racine, Schiller, Henry IV. (France), W. Herschel, Tasso, Jefferson, Ptolemy Claudius, Augustine, Pope, Machiavelli, Swedenborg, Philip II., Leonardo da Vinci, George III., Julian, Pythagoras, Macaulay, Rubens, Burns, Mozart, Humboldt, Comte, Cousin, Cuvier, Justinian, Euripides, Camoens.

Talleyrand, Fénelon, Carlyle, Pius IX., Pitt, More, Hannibal, Spinoza, Chateaubriand, Abelard, Grant, Charles I. (England), Darwin, Mazarin, Bolingbroke, *Elizabeth* (England), Ovid, *Joan d' Arc*, Livy, Corneille, Rabelais, Huss, a' Becket, d' Alembert, Grotius, Peter I., Polo, Linnæus, Raleigh, Palmerston, Lamartine, Jos. Bonaparte, Tennyson, Plutarch, Charlemagne, Aristophanes, Melanchthon, St. Ambrose, Richelieu, James I., Hunter, Hugo, Disraeli, Dryden, Origen, Titian, Boccaccio, Alberoni, Lessing, Fichte, Condillac, Dickens, Wallenstein, Schelling, Dürer, Charles XII., Kepler, Trajan, Knox, Constantine, La Fontaine, Van Dyck, Cervantes, *Staël*, Hippocrates, Louis XVIII., Clive, Rembrandt, Diderot, Chaucer, Montaigne, Napier, *Sand*, Marmont, Tiberius, Peel, Francis I. (France), Nicholas I., William I., J. S. Mill, Sophocles, J. Adams, Webster, Athanasius, Bentley, Savonarola, Marlborough, J. Cook, Seneca, Zwingle, Cavour, Buffon, Goldsmith, Brougham, Alexander VI., Gerson, Alexander I. (Russia), Louis XV., R. Bacon, Pericles.

Herodotus, Hadrian, Davy, Frederick II. (Germany), *Catherine II.*, Condé, B. Jonson, Antony, Lucretius, Pompey, James II. (England), Canning, Strafford, Mencius, La Fayette, A. Hamilton, Alfred the Great, Gassendi, Cortez, Beethoven, L. Bonaparte, *Sévigné*, Xenophon, Wycliffe, Alfieri, Charles X. (France), Harvey, Marius, Juvenal, Firdousee, Gutenberg, Lope de Vega Carpio, La Place, Garibaldi, Necker, Froissart, Arius, Æschylus, Etienne, Epicurus, Mithridates, Isocrates, Jerome, A. Jackson, Canova, Atterbury, Bulwer, Gay-Lussac, Wilhelm I. (Prussia), Niebuhr, Fielding, George IV., Haller, Schleiermacher, J. Watt, St. Bernard, William III., Joinville, Arago, Fouché, Handel, Spenser, Lagrange, Herder, Velasquez, Bunsen, Alcibiades, De Foe, Hastings, Colbert, Metternich, Richard I., Tertullian, Lamennais, Leo X., Cobden, Gustavus Adolphus, Wieland, Berkeley, Law, *Maintenon*, Cranmer, Coleridge, Chrysostom, Beza, Murat, Mazzini, Condorcet, Polybius, Ariosto, Chatterton, Pliny (Elder), Turgot, Tacitus, Malebranche, John of England, Danton, Chalmers, Germanicus, Haydn.

St. Basil, William of Orange, Longfellow, Philip IV., Sully, Huygens, Louis XI., Montesquieu, Eugene, Charles II. (England), Bernadotte, A. Severus, Klopstock, Innocent III., Zoroaster, Attila, G. Monk, A. Smith, Ney, Victor Emmanuel, Prescott, Pindar, Béranger, Gregory VII., Beaumarchais, Rossini, Bentham, Drake, Moreau, Faraday, Boetius, T. Moore, S. Clarke, Channing, Alexander II. (Russia), *Maria Theresa*, Wagner, Priestley, *Josephine*, Thackeray, Copernicus, Blücher, Soult, Maximilian, Carnot, Philo, Averroes, Calderon, Bolivar, Sulla, Ali-weli-zade, Le Sage, Heine, Boyle, Loyola, *Marie Antoinette*, Wesley, Poussin, Winckelmann, Turenne, R. B. B. Sheridan,

Weber, W. Hamilton, Avicenna, Shaftesbury, Bright, Catullus, Boerhaave, C. Grey, Leopold I. (Germany), W. Irving, Henry IV. (Germany), Tamerlane, Masséna, Retz, B. Constant, Reuchlin, Sainte-Beuve, Baxter, K. W. Humboldt, Jenner, Liebig, Philip II. (Germany), Aquinas, Dumouriez, Murillo, Lucian, Agassiz, Mehemet Ali, Wolsey, Solon, Jansen, Lavoisier, R. Walpole, Hogarth, Derby, Bichat, Sherman, Frederick W. III. (Prussia), St. Simon.

Wilkes, Phidias, Philip Augustus, Mendelssohn, Boniface VIII., Cobbett, Bailley, Emerson, Joseph II. (Germany), Russell, Vauban, Ferdinand V. (Spain), Bayle, Archimedes, *Christina*, Scipio, Thou, T. Fairfax, Metastasio, Louis IX., L' Hôpital, Marat, Guicciardini, Berzelius, Akbar, Sarpi, Varro, Armenius, Vergniaud, Bayard, Gregory I. (Pope), Louis XIII., Beaton, Wilberforce, Tieck, Andrews, Lycurgus, O'Connell, Burnet, Reynolds, Seward, J. Franklin, Galen, A. Dumas, Alaric, Campanella, Arnauld, Balzac, Plautus, a' Kempis, Richelieu, Pius VI., Terence, Charles VII. (France), Rénan, Pizarro, Henry II. (England), Martial, Theodosius, R. Blake, J. J. Scaliger, Cardan, Cowper, Musset, Pius II., Villars, Helvétius, Belisarius, Candolle, W. Temple, Palestrina, Robertson, Strauss, Kotzebue, Bach, Madison, Hesiod, George I. (England), Dupin, F. A. Wolf, St. Hilaire, Farragut, J. Q. Adams, Cato (Elder), Gluck, Grote, Cyrus, Bunyan, J. L. Grimm, L. Bonaparte, Antoninus Pius, Chesterfield, Pius VII., Leopardi, L. de Medici, Richard II., Gouvion St. Cyr, Gregory Naz., Warburton, Strabo.

Euclid, Desmoulins, *Genlis*, Clarendon, De Witt, Essex, Brahé, Eusebius, Mahmud II., Ferdinand VII. (Spain), Frederick I. (Germany), Euler, G. Howard, Reid, Gambetta, Ledru-Rollin, Lulli, Michaelis, Mahmud, Southey, Monge, Lucullus, Oersted, Hutten, Selden, Henry VI., Hawthorne, Villemain, Gall, Goldoni, Beaumont, Aguesseau, Beauharnais, J. F. Cooper, Catilina, Clement, J. B. Rousseau, Castlereagh, Fontanelle, Casaubon, Cellini, Charles VI. (France), L. R. St. Simon, Lavater, Jacobi, Herod, *Margaret of Anjou*, Philip VI. (France), Richter, Voss, Mackintosh, Lâo-Tsze, Paracelsus, Persius, Themistocles, J. C. Wolf, Ampère, George II. (England), Huskisson, Æschines, Albuquerque, Bruyère, Dalhousie, Suwaroff, Hampden, Coligni, Photius, Cudworth, Alva, Pufendorf, Rumford, Anderson, de Malherbe, *Mary*, J. B. Jourdan, Louis XII., Theodoric, Barrère, Titus, Ranke, Aurelian, *Gaskell*, T. Paine, Herbart, Lee, Phocion, *Mme. Roland*, Henry III. (France), St. Pierre, Ingres, Warwick, Garrison, Erskine, Halley, Cato (younger), Gustavus I., Vasco da Gama, Maupertuis, Guyon, Courier.

Albertus Magnus, Boehme, E. T. W. Hoffmann, T. E. Hook, Marot, Henry I. (England), Massillon, Quintilian, Monmouth, Mæcenas, Philip V., Michelet, Luxembourg, Tintoretto, Vespucci, Saladin, G. Buchannan, Henry V. (England), Butler, Anselm, Rochefoucauld, Charles the Bold, Manutius, Gustavus III., Cornelius, John of Austria, Delille, Adanson, Cherubini, Champollion, Mornay, Sieyès, H. Walpole, Jenghiz Khan, Magellan, William IV. (England), *Boleyn*, Ronsard, Meyerbeer, Ramus, Steele, Servetus, Orleans d' P., Gray, Josephus, Royer-Collard, F. C. M. Fourier, St. Francis, H. Clay, Gioberti, Desaix de Voygoux, Grattan, Montecuculi, Sacy, Bruno, Paley, Jerome Bonaparte, Barras, Maury, De la Vigne, Ali (Ibn abi talib), Cavaignac, Cromwell, Charles d' Orleans, Sterne, Malesherbes, Middleton, Vico, Berthollet, *Jane Grey*, A. Sidney, Salmasius, Pliny (younger), MacDonald, Sallust, Saxe, Marmontel, Clarendon, Sylvester II., J. Taylor, Lamarck, Holbein, Henry VIII., Volta, Rosa, Whiston, Haüy, Cyprian, A. Chénier, Diocletian, *Pompadour*, J. Herschel, Kaulbach, Poggio, Holberg, Miller, Henry IV. (England), Oehlenschläger, Boden, Manes.

Sappho, Sarto, Anaxagoras, ***Isabella of Castile***, A. W. Schlegel, Justin, Godoy, Epaminondas, P. Henry, Fulton, Dumont d' Urville, Garrick, Andrieu, Ginguené, Regnard, Du Guesclin, Wellesley, H. Vernet, ***George Eliot***, Fuller, Heraclitus, Newman, Struensee, Thorwaldsen, ***Cleopatra***, Zeno, Poushkin, E. Coke, Augereau, ***Brontë***, Jerome of Prag., Aurungzebe, Vespasian, Philopœman, Vane, Jouffroy, Bonnet, Giotto, Agrippa, Alcuin, Gregory of Nyssa, Proudhon, Politian, Arndt, Fréret, R. Hall, Charles IX. (France), ***Anne***, Smollett, Demetrius Polior, Democritus, Gay, Cabanis, J. Flaxman, Gallatin, Fouquet, Cujas Guido Reni, C. S. Gracchus, Jeffreys, Gardiner, Oxenstierna, Kléber, Scipio, Mabillon, Lacépède, Stewart, Lyell, Rameau, Cassini, Lalande, Sumner, Parker, Plotinus, Cagliari, Lacordaire, ***Marguerite d' Angoulême***, Kosciusko, P. H. Sheridan, Tocqueville, Hipparchus, Henry III. (England), Whitegift, Rudolph I., de Volney, Jugurtha, Prior, Ménage, Oken, Murray, Bellarmino, Churchill, Laffitte, Henry II. (France), W. Jones, J. Owen, Cecil, Darius I., Charles Edward Stuart, Donizetti.

Hammer-Purgstall, J. L. David, Propertius, Boileau, Leighton, Correggio, Grouchy, Francke, Lysias, Lannes, Bonner, Pichegru, Erigena, Casanova, C. de Medici, Nadir (Shah), Whitefield, J. P. J. d'Orleans, Lucan, Teniers, Richard III., Apelles, Meckiewitz, Ximines, Sobieski, E. Irving, Stein, Hoche, Louvois, Saadi, ***Montague***, Alfonso X., Scribe, Oudinot, Livingston, E. Herbert, K. W. F. Schlegel, Mariana, Rienzi, Sixtus V., Hahnemann, Celsus, von Gentz, Deák, Pym, Gustavus IV., Monroe, Gauss, Keats, C. Bell, Godwin, De la Croix, Charles VI. (Germany), Edward IV., Ennius, Epictetus, Ferdinand II., Harold II., Zeno, Fiesole, Pestalozzi, Dundonald, Tippoo Sahib, Clovis, Huet, Maistre, Cagliostro, Ray, Malthus, Atticus, Barrow, Somers, Arkwright, Wren, Quinet, Nodier, Krüdener, Bede, Claude of Lorraine, Theocritus, L. Stanislaus, Hooker, P. Sidney, Müller, Maimonides, Odoacer, Hénault, ***Theresa***, Barthez, Espartero, Decazes, ***Martineau***, T. Brown, Fermat, Agathocles, Empedocles, Charles V., Banks, Zinzendorf, Thierry.

T. S. Gracchus, Delambre, Caligula, Edward III. (England), Richardson, Porphyry, Nicole, Waller, Balboa, Solyman, ***Catherine de Medici***, La Harpe, Pole, Thales, ***Marie de Medici***, Procopius, Lactantius, Borgia, Berengarius de Tours, Tallien, Camden, Armstrong, Jeffrey, Capo, Sismondi, R. Owen, Apuleius, St. Just, Spontini, W. Laud, Irenæus, Lacretelle, J. B. Lulli, Paul I. (Russia), Stilicho, Arbuthnot, Dampier, Auber, Grégoire, Dolet, La Chaise, Francis II. (Germany), Dolomieu, Æsop, F. M. Grimm, Dupuytren, M. J. Brutus, Feuerbach, Barnaveldt, Farel, Akenside, Prince Albert, Bouillon, Hauser, Frederick Wilhelm II. (Prussia), Gerando, W. Wallace, Chamfort, Agrippa, Garat, Audubon, A. Doria, Hareeree, Cowley, Heyne, Martinez, Petronius, ***Hortense***, Mahommed II., Mai, Sue, J. Barry, Marivaux, Sebastian, Rotrou, W. Russell, Suchet, Paoli, Bopp, Romilly, Montalembert, John XXII., Rohan, Iamblicus, Bernhard, Simonides, Baggesen, Raspail, Thomson, Louis I., Otho, Sertorius, Macpherson, Claudianus, Domitian, Bugeaud, Charles I. (Naples), Fauriel, Enfantin, Babeuf.

The preparation of this list was incidental to the main purpose of my research, and I do not wish to lay undue stress upon it. Still it is of interest to find that we can compare and even measure a thing as intangible as the eminence of great men. We should not need to refer to such a list to decide whether Homer or Virgil is the more eminent; but it may satisfy that curiosity which is the beginning of science to

know that there are to the best of our present knowledge twelve men more eminent than Homer and fifty-six men more eminent than Virgil. Further by reckoning the probable errors it is found that the chances are even that Homer's place on the list is between 10 and 26 and Virgil's between 42 and 98.

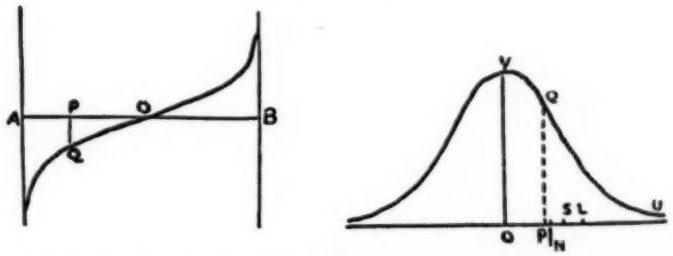
But while our general knowledge apart from any such list as this may suffice to compare Homer with Virgil as accurately as is needful, this does not hold for men whose work is not readily comparable. Is Raphael, Descartes or Columbus the more eminent? As a matter of fact they stand respectively 22d, 23d and 24th on the list, and are equally eminent. I do not see how this result could have been reached from any general knowledge we may have of the work and fame of these men. Or again, Newton follows Homer and Hume follows Virgil on the list, consequently Newton is as much more eminent than Hume as Homer is than Virgil.

Things can be arranged in order more easily than they can be measured. We know that one sound is louder than another, though we may be unable to say whether it is more or less than twice as loud. We can arrange without much difficulty the examination papers of our students in the order of excellence, though unable to decide that one paper is twice as good as another. But the theory of probability makes even the measurement of the eminence of great men possible.

If all the men of the races and ages with which we are concerned were arranged in order, we might divide them into quarters. Supposing there to be one hundred million individuals in all from whom these men might have arisen, taking the adult male population of the countries and periods producing nearly all of them, we should have at the end the 25 million least deserving of credit, including the defective and delinquent classes. Then we should have two groups each containing 25 million, one falling below and one rising above the average. These are the ordinary men who depart from the median by an amount less than the probable error. Then at the upper end we have the group of 25 million individuals who through some special trait or through a combination of traits rise above the others. At the extreme end of this group are the thousand preeminent men of our list.

What a man is and does is the result of innumerable influences, chiefly small and independent, some pulling him down and some lifting him up. In so far as this is the case, the men will be grouped together and depart from each other in a certain definite fashion. The matter can most readily be illustrated by taking a single trait such as height. If these men were placed in a row arranged according to height, the tops of their heads would form a curve of which an exaggerated form is given. In a general way the middle man would be of the average height,

say 5 ft. 8 in., and a great part of all the men would be of nearly this height, one quarter being not more than 1½ inches shorter and one quarter not more than 1½ inches taller. The line of the heads would be nearly horizontal, but would gradually slope more and more, until at one end we should have the comparatively few dwarfs and at the other the few giants. These relations can be illustrated by the bell-shaped curve, whose properties are well known.



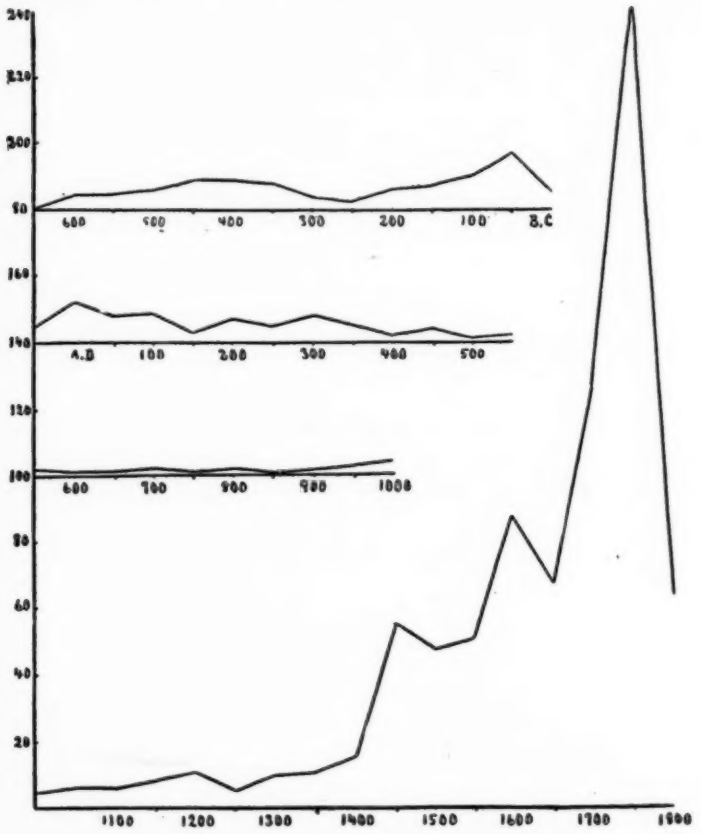
OGIVE AND BELL-SHAPED CURVES SHOWING THE DISTRIBUTION OF TRAITS.

Five feet eight inches is the average height of men, and the number of men of that height (within say 1/10 in.) is proportional to the line *OY*. The number of men say 1½ inches (within 1/10 in.) larger than the average by an amount equal to the probable error or 1½ in. is proportional to the line *PQ*, and the number of men within these limits, one quarter of all the men, is proportional to the area *OYQP* which is one quarter the area of the curve. The number of men 6 ft. 2 in. in height—who depart from the mean by 6 in., or four times the probable error—would be *OU*, only 1/50 as many as are 5 ft. 9½ in. in height, and but three in a thousand of all men would be taller than 6 ft. 2 in.

Now applying this to the collective traits giving efficiency, we have one half of all men coming within the limit *OP* which may be taken as a unit of measure. The total number of men surpassing the average by four times the amount of the average departure would be about 300,000. Most of us may hope to fall within this group. The thousand preeminent men filling the extreme area of the curve would begin at a point six times the average departure, and the relative excellence of the greater men on the list can also be expressed numerically.

Turning now to the distribution of these eminent men in time and race we may review statistics not wholly devoid of interest. The number of great men born in each half century since the beginning of history is shown in the accompanying curve. In still more remote ages there were leaders of men, gods, prophets and heroes, whose names are forgotten or obscured, and at the beginning we have four names, representing rather work than persons—Zoroaster, Homer, Hesiod,

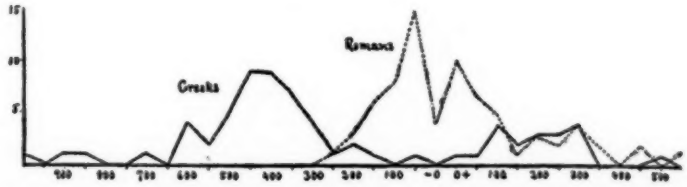
Lycurgus—followed by the rise of Greek civilization and culture—the most notable event in the world's history. Here we have a race as superior to us as we are to the negroes—a great race, for whose origin we can no more account than we can explain the birth of Shakespeare at Stratford-on-Avon. The curve shows the progress of the Greek race as represented by its great men—leaders then and now in war, in



THE CURVE REPRESENTS THE DISTRIBUTION OF THE THOUSAND MOST EMINENT MEN OF HISTORY FROM 600 B. C. TO THE FIRST HALF OF THE NINETEENTH CENTURY. The numbers are given on the left side, the ordinates or height of the curve above the base line representing the number of eminent men born in each half century. Thus there were five preeminent men born between 600 and 550 B. C. and 241 in the second half of the eighteenth century. As men attain eminence about fifty years later than they are born, the periods of productivity are one place further to the right.

statesmanship, in philosophy, in literature, in art—and its more sudden decline in the third and second centuries before Christ. But the supremacy relinquished by the Greeks was grasped by the iron hand of the Romans, who in the centuries just before Christ rise rapidly and then fall. The relation of Greek to Roman civilization is shown in a separate figure.

These curves—which of course give only a graphic representation of quantitative relations whose general character we all know—indicate that heredity, including under the term both stability and variability of the stock, is more potent than social tradition or physical environment. We have these races forming by their own inherent genius a social environment far beyond anything the world had ever witnessed, but when this was at its maximum it had not power to counteract the weakening influence of race admixture and exhaustion of the stock. The physical environment also remained the same, and those who would account for Greek and Roman culture by the favorable position of the two Mediterranean peninsulas—their climate, soil, coast line



THE CURVES SHOW THE DISTRIBUTION OF EMINENT MEN IN THE GRECO-ROMAN PERIOD.

and the like—should tell us why these could not maintain what they had formed. Why should the Greeks then have resisted the countless hordes of Persia, while recently on the same ground they fled before a few thousand Turks? Physical environment and social tradition may be conditions of development, but they are not its efficient causes.

Following the extraordinary development of the two nations of classical antiquity we have a decline, not sudden, for Rome still produced soldiers and writers, the Christian Church had its leaders and theologians, and the Greeks witnessed their Indian summer in Alexandria. But the light fails toward the fifth century—never, however, to be quenched, for there were always one or two to pass on the torch until the fire was rekindled in newer races. In Britain, in Germany and in France there developed centers of civilization. The mixed races of Italy gave birth to an art and a literature rivaling that of Greece. The Roman Catholic Church fairly established its authority by the great men it produced. It was a strange time, all Europe was in turmoil, but universities were established and the arts of peace flourished in the midst of wars.

The curve shows a rise from the tenth century increasing in rapidity as it proceeds. As the list includes only men no longer living, and as many of those born during the first half of the nineteenth century were still living and had not even attained eminence when the books of reference on which the list is based were compiled, the absolute numbers of those born since 1800 have no value, but they serve for comparison

The increase in eminent men as we approach our own day may be partly a matter of perspective. Still the numbers should normally increase with larger population and multiplication of opportunity and interests. It is unfortunately very difficult to compare the number of great men with the total population from which they arose. Were a curve of this sort drawn, however, it would be very different from that here exhibited. The rise in modern times would be much less; and the Greek and Roman periods would surpass that of the end of the eighteenth century.

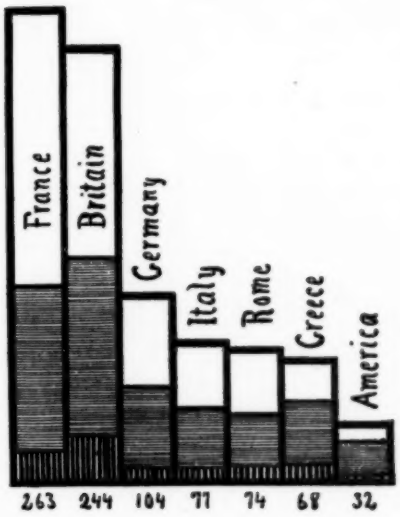
In our curve there are three noticeable breaks. Perhaps nothing could serve better than such a curve to impress on the minds of school children, or even on our own, the eddies in the stream. It must be remembered that the curves give the numbers of men born in each half century, while the period in which they flourished is about fifty years later. Thus in the fourteenth century there was a pause followed by a gradual improvement and an extraordinary fruition at the end of the fifteenth century. Painting is represented in Italy by Raphael, Angelo, Leonardo, Titian, Correggio and Sarto, in Germany by Holbein and Dürer. Savonarola failed, while Luther led a reformation. Columbus discovered a new world and Copernicus discovered innumerable worlds. There was then a pause in progress, until a century later England and France took the lead. Spenser was quickly followed by Shakespeare, who did not stand alone among English dramatists. A little later Molière, Racine and Corneille represented the drama in a group of eminent French men of letters. Descartes and Bacon revived philosophy and science; while Italy, failing in art, produced Galileo.

The latter part of the seventeenth century was a sterile period, followed by a revival culminating in the French revolution. Here, as in other periods, it is difficult to decide how far men were made eminent by circumstance and how far great men were leaders in new movements. The social upheaval in France gave eminence to political and military leaders who otherwise would have remained in obscurity, and given a Napoleon his complement is a Wellington. The progress of science may in part be an answer to the demands of increasing population. But philosophy and art also witnessed a renaissance. In Germany we have Kant, Goethe and the development of music, in England, poets speaking a new language. Here great men seem not so much the creatures as the creators of their environment.

As we come nearer to our own times it becomes increasingly difficult to measure tendencies by the methods we are using. The positions of men on the list are subject to larger probable and constant errors. Byron may be a household word on the continent and Shelley unknown, while the best criticism may place Shelley above Byron. Our list places Mendelssohn above Bach and ignores Schumann altogether—

while the last thirty years have altered not only critical opinion, but also popular taste.

If we regard now more especially the racial distribution of our great men, we get results conveniently exhibited in the accompanying figure. The heights of the rectangles are proportional to the numbers of great men produced by several nations. France leads, followed pretty closely by Great Britain. Then there is a considerable fall to Germany and Italy. Rome and Greece are nearly alike. America has produced one more eminent man than Spain (not on the chart) which is followed by Switzerland, Holland and Sweden. We then reach the nations headed by Russia, which have produced fewer than 10 preeminent men. The shaded rectangles show the distribution of the 500 men who are the most eminent and the heavily shaded rectangles the hundred who are the greatest of all. Here the relations are somewhat altered. Great Britain surpasses France, and Greece has produced more exceptionally great men than Germany.*

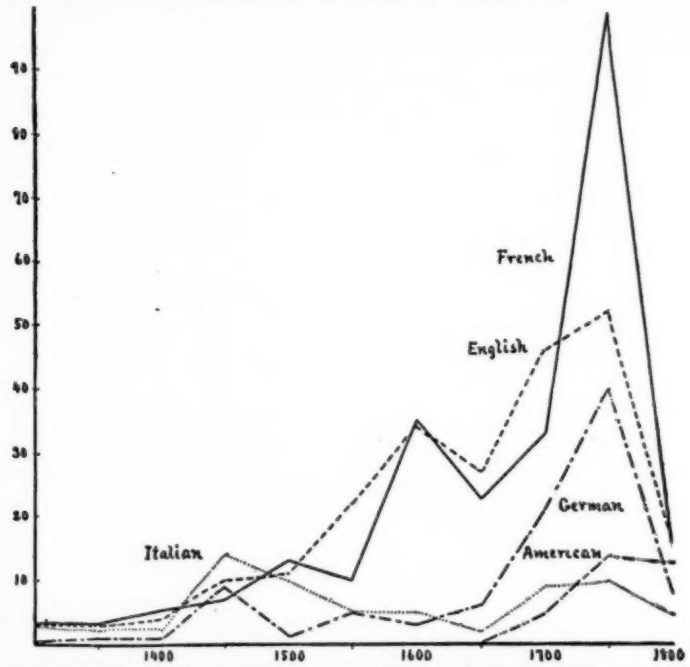


THE RECTANGLES ARE PROPORTIONAL TO THE NUMBERS OF THE MOST EMINENT MEN PRODUCED BY DIFFERENT NATIONS. The shaded parts represent the more eminent five hundred, and the heavily shaded parts the hundred most eminent of all.

We have already noticed the curves showing separately the Greek and Roman periods. Similar curves for the leading modern nations are given in the chart. The Italian renaissance is followed by its decadence with a partial revival in recent times. Germany for one short period in the fifteenth century rivaled France and England, but in the two following centuries lagged far behind, to rise with great rapidity in the eighteenth century. France and Great Britain, as we have seen, have produced nearly the same number of great men, and their curves during the centuries cross and recross. The British curve is somewhat more regular than the French, exhibiting perhaps certain racial characteristics. As has been already stated, the French revolution brought into prominence many men not truly great, and the position then attained by France is not held in the nineteenth century. In so far as the curves

* These relations are somewhat dependent on the authorities collated; their validity may be assigned by the calculation of probable errors, but there may be a constant error due to the fact that the collation of names depends chiefly on French and Anglo-Saxon standards.

for the nineteenth century are valid, the promise for America is large. We should during the twentieth century produce more notable men than any other nation. It is ill for us, having the largest population and the richest resources, if we do not keep this promise.

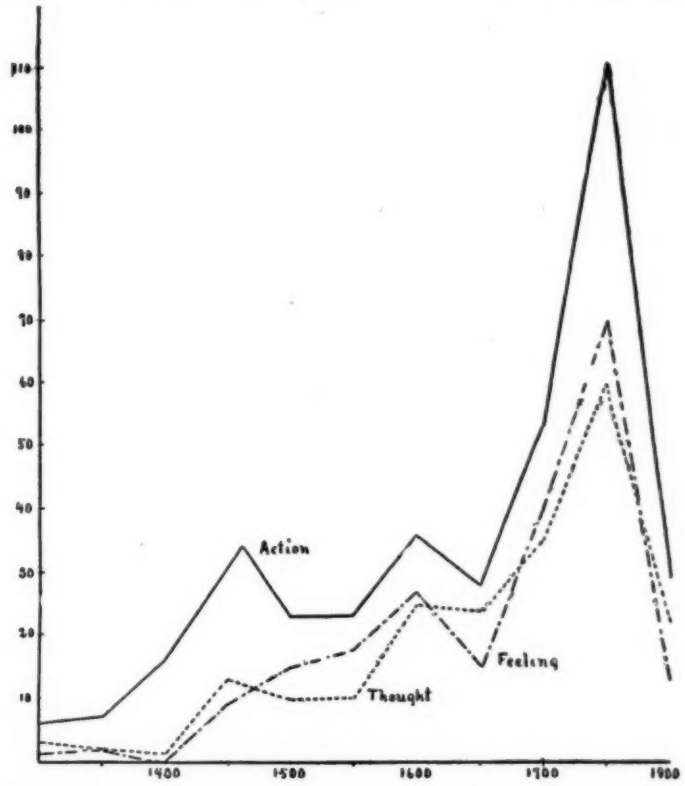


THE CURVES SHOW THE PRODUCTION OF GREAT MEN AT DIFFERENT PERIODS BY SEVERAL OF THE LEADING NATIONS.

Our racial divisions are given to us ready made. The subject becomes more difficult when we try to class eminent men in accordance with their traits. We can, however, perhaps use the tripartite subdivision current in psychology. There we are apt to treat separately cognitions, feelings and volitions. This classification proves useful when applied to the traits of great men. Some excel because they have strong wills, are quick and sure in action. These become leaders in war and in political affairs. Others have strong feelings—artists, poets, men of letters. Others surpass in pure thought—philosophers, scholars, men of science. Distinguishing then men of action, men of feeling, and men of thought, we secure the curves shown on the accompanying chart. It is seen that more men are eminent for action than for either thought or feeling, though if the latter two classes are combined it is found that the quiet work of the student has after all produced more eminent men than war and politics. Each class shows an increase as we approach our own time and the secular variations affect them together, though it is noticeable that men of thought have been

much more constant in their appearance and bid fair to surpass the others in the twentieth century.

In passing I may state that modern psychology does not admit that we can divide mental processes into such as are cognitions, such as are feelings and such as are volitions, any more than we can divide physical bodies into such as have size, such as have color and such as have weight, but must rather regard these as aspects of all mental processes. So

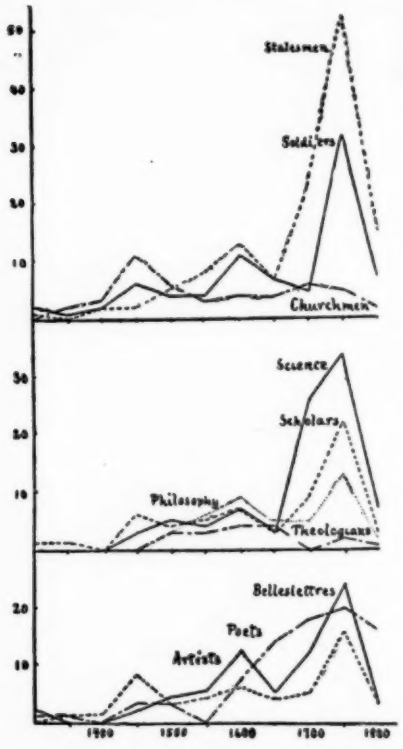


THE CURVES SHOW THE RELATIVE NUMBERS OF MEN OF ACTION, MEN OF THOUGHT, AND MEN OF FEELING AT DIFFERENT PERIODS.

with our great men—if a man excels in action he probably is not deficient in feeling and judgment—on the contrary these are probably strong. My statistics show, contrary perhaps to the current opinion, that a man who excels in one direction is likely also to excel in others. An artist is much more likely to be a poet than is an ordinary man and is, though in a less degree, more likely to be a soldier or a man of science.

Curves showing further subdivisions are also given. From the upper chart it is clear that there have been more eminent statesmen than soldiers, especially since the beginning of the eighteenth century.

Soldiers are also surpassed in numbers by men of science and our curves foretell the gradual cessation of wars. Churchmen and theologians are of decreasing importance in human affairs. It is interesting to note that the sterility at the end of the seventeenth century and the subsequent revival hold for nearly every separate department. Fiction and belleslettres make the only exception, their growth in the seventeenth and eighteenth centuries continued in the nineteenth century, and the number of prose writers, novelists, essayists and the like, who attained eminence in the past century, surpasses that in any other department. Any librarian can confirm this by telling what books are most read. Poetry and art seem to be failing. Next to politics and belleslettres, science occupies the most important place.



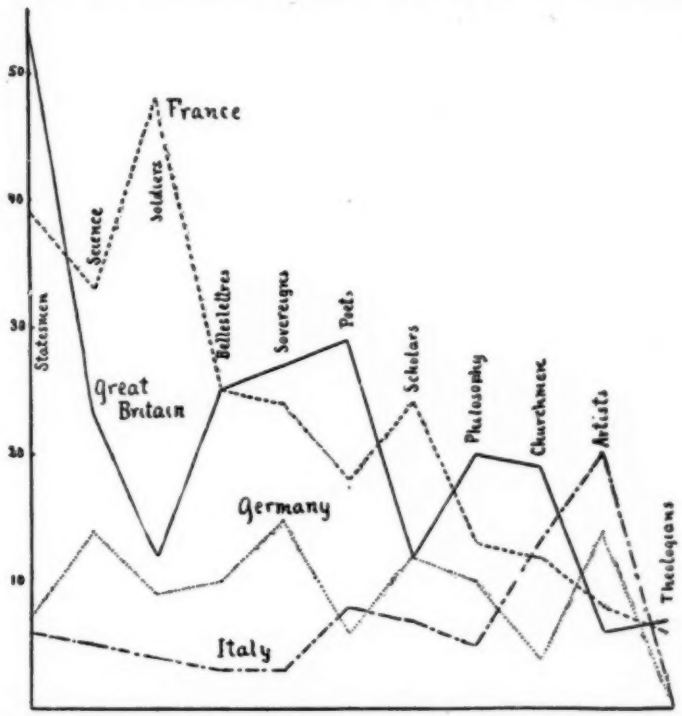
THE CURVES SHOW THE DISTRIBUTION OF MEN OF ACTION, MEN OF THOUGHT AND MEN OF FEELING, SEPARATED INTO GROUPS FOR DIFFERENT LINES OF ACTIVITY.

The first five hundred were separated from the five hundred less eminent men, but they were found to be nearly equally divided in the different classes, except that there are more very great poets and fewer very great men of letters.

The accompanying chart shows the contributions of different nations to different departments. It is evident that France has excelled in war, in belleslettres and in science—England in politics, in poetry and in philosophy—Italy in art. Germany has produced ten and Italy six of the eighteen great musicians. Of the fourteen great explorers England has produced five and Spain four.

There are two somewhat anomalous classes of eminent men which I have not as yet mentioned. Hereditary sovereigns and those made eminent purely by circumstance. The hereditary sovereigns included are of course only the more eminent, 102 in all, but they can not be compared with the other classes. Only eight have been included under the class of those eminent by circumstance, of whom Casper Hauser is typical—but several others, especially the wives of kings, might be placed there.

I have spoken throughout of eminent men as we lack in English words including both men and women, but as a matter of fact women do not have an important place on the list. They have in all 32 representatives in the thousand. Of these eleven are hereditary sovereigns and eight are eminent through misfortunes, beauty or other circumstances. Belleslettres and fiction—the only department in which woman has accomplished much—give ten names (of which three are in the first 500) as compared with 72 men. Sappho and Joan d'Arc are



THE CURVES SHOW THE RELATIVE CONTRIBUTION OF DIFFERENT NATIONS TO DIFFERENT LINES OF ACTIVITY.

the only other women on the list. It is noticeable that with the exception of Sappho—a name associated with certain fine fragments—women have not excelled in poetry or art. Yet these are the departments least dependent on environment and at the same time those in which the environment has been perhaps as favorable for women as for men. Women depart less from the normal than man—a fact that usually holds for the female throughout the animal series; in many closely related species only the males can be readily distinguished. The distribution of women is represented by a narrower bell-shaped curve.*

* Since the above was written Professor Karl Pearson has questioned the lesser variability of woman. The matter can only be decided by facts; these statistics certainly show greater variability for the male.

This paper is only preliminary to the real object of my research. We have many books and articles on great men, their genius, their heredity, their insanity, their precocity, their versatility and the like, but, whether these are collections of anecdotes such as Professor Lombroso's or scientific investigations such as Dr. Galton's, they are lacking in exact and quantitative deductions. Admitting that genius is hereditary, or, what is more doubtful, that it is likely to be associated with insanity, we have only the 'yes' or 'no' as our answer. But this is only the beginning of science. Science asks how much? We can only answer when we have an objective series of observations, sufficient to eliminate chance errors, such as this list of a thousand preeminent men.

When we have such a series we can use what psychological insight we possess to classify our material. We can seek to distinguish genius from talent, and, having given these terms a more exact signification, can secure quantitative data regarding their relative frequency under varying conditions. We can determine how the man of unusual endowment in its various manifestations differs from his fellow men, both in those traits which distinguish him from them and in those traits which he shares with them. With traits that can be measured such as length of life, height, etc., we can readily compare the several classes of eminent men with other classes in the community. In the case of other traits, insanity for example, we must first determine its prevalence, according to a proper definition, in the various classes of eminent men and can then give a definite statement as to its relative frequency among them and a comparison with other classes. Other more intangible traits I am also endeavoring to measure. Qualities such as originality or kindliness are graded on a scale of eight, mistakes are eliminated by the numbers and we secure fairly reliable averages. The different classes of eminent men can then be compared *inter se,* and with other classes of the community, when the data for these are at hand. Then we have the distinctions on which I have already dwelt. We can only determine the causes of great men and their effects by a careful study of a number sufficiently large to eliminate accidental causes and errors in our estimate; but having done this, our results can be expressed in the definite measures of exact science.

In conclusion attention may be called to the practical importance of such determinations. Science must precede the applications of science. The father must discover the laws of the pendulum before the son can apply them to the clock. A Faraday and a Henry must investigate the phenomena of electricity before we can have the electric motor. It is evident that applications of psychology and sociology are not as yet numerous or important. But may not this be chiefly because the scientific principles are wanting? Education and government are carried

on by the rule of thumb, not because this is the best way, but because we lack the knowledge to prescribe a better way. The struggle for existence, careless of the individual, proceeds with reckless waste of life, and it is only the fit that survives, and not what we regard as the best. The Chinese civilization of the age of Confucius was more stable than that of classical Greece. The progress to our present civilization may have depended largely on the comparatively few men who have guided it, and the civilization we hope to have may depend on a few men. Can we not with the knowledge we have and with the knowledge we should acquire do more to produce such men, to select them, to train them and to use them?

We can not perhaps apply the methods of horticulture to society, nor carry Plato's Republic into effect. But great men tend to be proportional in numbers to the total populations producing them and to the average of the stock. If we can improve the stock by eliminating the unfit or by favoring the endowed—if we give to those who have and take away from those who have not even that which they have—we can greatly accelerate and direct the course of evolution. If the total population, especially of the well endowed, is larger, we increase the number of great men. We should make sure that all are given such preliminary education and opportunity that none fail through lack of these. Lastly great men and also the well endowed should be so placed that their abilities are not spent on trivial or selfish ends.

We may have still stocks that are immature—the Slavs, the Czechs and the Scandinavians—and there is a possibility of vitality in the negroes. But we have finally broken the links between us and the lower animals. When our stock is exhausted, when there are no longer variations towards what we regard as advance, then for thousands of years the human race may be dependent on the social tradition now set. We are perhaps beginning to fail in art and in poetry, but for a century or more science and its applications will probably be at their maximum. What is accomplished during this short period must be either the foundation for a new stock or the endowment policy for a long old age.

SCIENTIFIC LITERATURE.

BIOGRAPHIES OF EMINENT CHEMISTS.

BESIDES the individual works named in recent numbers of THE POPULAR SCIENCE MONTHLY, the collected works, or dictionaries, of biography, particularly those treating specially of scientific men, contain valuable information of the lives and labors of the chemists. So far as known to the writer there is only one book devoted to chemists exclusively, and that one is so full of mistakes and so weak through its omissions of conspicuous men of all nationalities, especially Americans, that it could only be named for the purpose of condemning it. Suffice it to say the book is of German origin, yet it does not include all the honorary members of the German Chemical Society. The fact that it is of recent origin and is issued by a prominent publisher does but strengthen its weakness.

The most valuable of all biographical dictionaries dealing solely with men of science is also of German origin, and owing to its unwieldly title is usually designated by the words: 'Poggendorff's Dictionary.' The 'Biographisch-literarisches Handwörterbuch zur Geschichte der exakten Wissenschaften,' begun in 1858 by J. C. Poggendorff, and continued to 1900 by Feddersen and von Oettingen, now comprises three large volumes, and another is promised; it is most comprehensive, including all nationalities, all epochs of history and all branches of *exact* science. Under the last heading, however, as interpreted by its originator, the dictionary does not include biology, so that with few exceptions, botanists and zoologists, as well as physicians, are omitted; otherwise for mathematicians, astronomers, geologists, physicists and chemists it is most valuable. This dictionary not only gives very brief outlines of the lives of those catalogued, but in addition, fairly full lists of their scientific publications both in independent books and in periodicals. To the historian, and the student of the literature of sciences within the categories named, these volumes are indispensable; together with 'Who's Who in America' they form a *vade mecum* with reference to the dead and the living actors in science. If a personal remark may be here permitted, the writer will venture to add that his copy of 'Poggendorff's Dictionary' has been enhanced in value by the insertion of more than six hundred engraved portraits of savants, each one adjoining the appropriate biography, thereby doubling the number of volumes and increasing the interest of the reader.

Several works are particularly admirable for the abundance of the portraits of scientists within their covers; among these may be mentioned the four volumes published in 1833–40 by the Philanthropic Society, 'Montyon et Franklin,' containing likenesses not easily found elsewhere, and Figuier's 'Vie des savants' in five volumes, containing many portraits and illustrations in which imagination has been of great assistance to the artist. Hofmann's 'Erinnerungen an vorangegangene Freunde' (three volumes, 1889) embraces sketches of the lives of chemists only, illustrated by portraits, which unfortunately are not well engraved, though the text is that of a master as well as a sympathetic friend appreciative of the scientific work of those he portrays. The biog-

raphies by Hofmann include Graham, Liebig, Buff, von Fehling, Wöhler, Dumas, Quintino Sella, Kirchoff and Wurtz, as well as some of his own pupils; besides portraits of these chemists the volumes contain facsimiles and other illustrations.

Of English scientists living at the beginning of the nineteenth century there exists a very large, handsomely engraved print, which represents the men assembled in the Royal Institution; this was designed by Gilbert and drawn by Skill and W. Walker, the latter of whom being also the engraver; it was published in June, 1862. It contains fifty portraits, including twelve distinguished chemists, Cavendish, Dalton, Davy, Rumford, Watt, Wollaston, Rutherford and others; and is accompanied by a key and a volume giving biographies of all the scientists whose portraits are given. The book is edited by William Walker, junior, and with the print forms a most valuable publication of artistic merit.

Of American scientists the chief treasury for portraits and biographies are the volumes of THE POPULAR SCIENCE MONTHLY as is well known to our readers. From the pages of this journal the late editor compiled a handsome book of over five hundred pages, entitled 'Pioneers of Science in America' (New York, 1896), and embracing sketches of forty-nine eminent men; the excellent portraits in this work were in large measure drawn and engraved expressly for it, and some of them can scarcely be found elsewhere.

In concluding these desultory comments on biographies of eminent chemists, begun in the April number, mention must be made of two more volumes of interest; 'Essays in Historical Chemistry,' by T. E. Thorpe (London, 1894), might be more accurately entitled essays in chemical biography, for the volume consists of addresses and lectures dealing with the lives and scientific labors of twelve distinguished chemists, from Hon. Robert Boyle, the 'Father of Chemistry and Brother to the Earl of Cork,' to Dimitri Ivanowitsh Mendeléeff, the Russian whose name is memorably linked to the periodic law. Dr. Thorpe's essays are gracefully written and read well, but he has not always taken pains to verify his statements. The assertion, for example, that Claudio Bereguardi made experiments with the barometer on the leaning tower of Pisa (prior to Torricelli's invention) is a myth.

The second work to be named in conclusion is entitled 'Memorial Lectures delivered before the Chemical Society [of London]' (London, 1901), to which allusion has already been made; it contains masterly sketches of the lives and labors of twelve of the most eminent chemists who have died within the last decade, each written by a sympathetic friend or by one whose investigations were analogous. This work can be cordially commended as the most recent, authoritative and comprehensive volume published on the subject. Fine portraits embellish the valuable contribution to chemical biography.

THE PROGRESS OF SCIENCE.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE first convocation week meeting of the American Association and its affiliated societies was a notable event in the progress of science in America. We have on several occasions called attention to the circumstances that led up to this meeting. The American Association with its affiliated societies has hitherto held its meetings in the summer, when the dispersal of men of science and the heat have been disturbing factors. The American Society of Naturalists with its affiliated societies has met during Christmas week when the time was too short, especially for those who traveled from a distance. The American Association was successful in securing a short extension of the Christmas holidays from all our leading institutions of learning, some seventy in number, leaving free for the meetings of scientific and learned societies the week in which the first of January falls. The American Association and the American Society of Naturalists and most of the national societies devoted to the special sciences then united to hold the great congress which met at Washington from December 29 to January 3.

There were at the meetings more scientific men than had ever before assembled on this continent. The enrolment of members of the association was 989, which was increased to 1,352 by the registration of those attending the meeting of affiliated societies, but not members of the association. The attendance was larger than the registration, and may be estimated at considerably more than 1,500. The addresses, papers and discussions were truly bewildering in their number and range. There were about thirty-five special societies and sections of the association meeting nearly or quite simultaneously. Under these circumstances conflicts and inconveniences were not entirely absent, but on the whole the complicated machinery worked with remarkable smoothness. Such a great meeting accomplished much in promoting solidarity among men of science, and in demonstrating their activity and power of organization to the world. It was especially fortunate that this meeting should have been held at Washington, which is now the scientific, as well as the political, capital of the country. Men of science from all parts must have been greatly impressed by the immense quantity and admirable quality of scientific work being done under the national government, whereas the government officers must have been encouraged in their research by the visitors.

A number or even a volume of the MONTHLY would go but a small way toward publishing the addresses and papers presented at the Washington meeting. We print elsewhere the address of the retiring president, Professor Asaph Hall, one of the world's great astronomers. Other addresses and abstracts of the proceedings will be found in *Science;* the real scientific work of the meeting, however, must be looked for in the special journals and series of publications.

Dr. Carroll D. Wright, U. S. Commissioner of Labor, was chosen as the next president, and St. Louis as the next place of meeting. The range of the association and its affiliated societies was demonstrated by both selections.

For the first time social and economic science was recognized in the election to the presidency, whereas the place of meeting acknowledged the middle west as coordinate with the east in its scientific activity.

THE RECOGNITION OF THE IMPORTANCE OF PREVENTIVE MEDICINE.

WHILE it is quite impossible to give an account of the multifarious activities of the association, what may be accomplished by organized science may be illustrated by two resolutions passed by the council. One of these recognized the service of the late Major Walter Reed in exterminating yellow fever at Havana, the other emphasized the need of expert medical supervision in the construction of the Isthmian Canal.

The first resolution reads:

RESOLVED, That the American Association for the Advancement of Science hereby records its sense of the great loss sustained by science in the death of Major Walter Reed, surgeon in the United States Army, and its appreciation of the far-reaching and invaluable services which he has rendered to humanity. By solving the problem of the mode of spread of yellow fever, Major Reed not only made a great contribution to science, but at the same time conferred inestimable benefits upon his country and upon mankind. To have discovered and demonstrated the methods, which have already been successfully tested in Cuba, of eradicating a wide-spread and terrible pestilence, is a benefaction of imperishable renown, of incalculable value in the saving of human lives, of vast importance to commercial interests, and deserving of the highest rewards in the power of his countrymen to bestow. This association earnestly urges upon the attention of Congress the duty of making full provision for the support of his family.

RESOLVED, That the President designate a committee of nine members of this Association, with power to increase its number, which shall be authorized and requested to devise and carry out a plan, or aid in similar efforts elsewhere instituted, by which a suitable and permanent memorial of this great benefactor of his race may be secured. This committee shall be authorized to prepare and publish a statement of the services of the late Major Reed in discovering the mode by which yellow fever may be exterminated.

The members appointed to serve as such committee are: Dr. D. C. Gilman, Dr. A. Graham Bell, General George M. Sternberg, Mayor Seth Low, Hon. Abram S. Hewitt, President J. G. Schurman, Dr. S. E. Chaillé, Dr. W. H. Welch, Dr. Charles S. Minot.

The second resolution was as follows:

Inasmuch as the construction of the Isthmian Canal is through a region in which without energetic sanitary control there is sure to be enormous loss of human life from preventable diseases, particularly from pernicious malaria and yellow fever, as well as great waste of energy and of money from disabilities caused by such diseases, and

Inasmuch as the measures for the restraint of these diseases, which have already achieved even their extermination in Cuba under American administration, require expert knowledge based upon practical familiarity with tropical diseases, experience in the application of these measures, and large authority in their administration,

RESOLVED, That the American Association for the Advancement of Science begs most respectfully and earnestly to call to the attention of the President of the United States the importance of appointing as a member of the Isthmian Canal Commission a medical man possessed of the qualifications indicated. The association is convinced that the mere employment of such a sanitary expert by the commission will not be likely to secure the desired results.

RESOLVED, That the permanent secretary of the association transmit a copy of these resolutions to the President of the United States.

A NEWLY RECOGNIZED FACTOR IN AMERICAN ANEMIAS—'THE GERM OF LAZINESS.'

UNDER the sensational heading of 'the germ of laziness,' the daily press has been endeavoring to tell the public something about a new discovery made by the U. S. Public Health and Marine Hospital Service. Owing to the wording of the first report, by the New York *Sun*, many newspapers have not known whether this alleged discovery should

be taken seriously or in jest, and the editorial remarks upon the subject have, therefore, varied from the serious to the sarcastic. The following are the facts of the case, as learned by the POPULAR SCIENCE MONTHLY from a reliable source.

The Eber's Papyrus, an Egyptian manuscript, about 3,500 years old, described a tropical malady as the 'A A A' or the 'U H A' disease, which is characterized by an extreme anemia, pains in the abdomen, palpitation of the heart, and certain other symptoms. This same disease is described by various authors in the eighteenth century, but its cause was not discovered until 1843, when Dubini, of Milan, found a parasitic, roundworm which inhabits the intestine and which he named *Anchylostoma duodenale*. This worm belongs to the strongyles and is closely related to the 'hookworm,' *Uncinaria vulpis*, described by Frölich in 1789.

It has been thoroughly established that Dubini's hookworm sucks the blood and produces a poison; also that it causes the conditions known under the various names of St. Gothard anemia, miner's anemia, brickmaker's anemia, Egyptian chlorosis, uncinariasis, anchylostomiasis, etc. This disease is known to be very prevalent in tropical countries, but curiously enough no positive case in the United States was recognized as such until 1893, when Dr. Blickman, of St. Louis, found a German who had brought the infection with him from Europe. Dr. Stiles, zoologist of the Public Health and Marine Hospital Service, has maintained for eight or ten years that this disease must be more or less common in the southern portion of this country, and that physicians have undoubtedly confused it with malaria. This view, which he has repeatedly defended before medical and scientific audiences, has been looked upon as extreme and has not been adopted by the American practitioners. Isolated cases of the disease were reported occasionally, but between 1892 and 1902 only about 35 cases were found in the United States, and most of these were imported. Dr. Ashford had, however, shown that the disease is common in Porto Rico. In May, 1902, Dr. Stiles obtained the parasites from three cases which occurred respectively in Virginia, Galveston and Porto Rico, and he showed that they were not identical with the parasite which causes miner's anemia in the Old World. He described this new worm as *Uncinaria americana*, and using Virginia, Galveston and Porto Rico as the three angles of a triangle, he maintained that this area must harbor a more or less common disease caused by the new parasite. In September, 1902, he started out to demonstrate the correctness of this view and in eight weeks time he proved his point.

The extreme and in some cases nonsensical statements made by the daily press have been startling, but not more so than the more serious and conservative statements Dr. Stiles made before the medical society to which he presented his results. The press has, however, misquoted his statements in more than one particular. His results briefly stated are these:

If we go south from Virginia to the gulf we meet two totally different kinds of anemia, which can be distinguished by the soils on which they occur, the parasites which cause them, the symptoms which result, and the treatment which is necessary. One of these anemias follows the more impervious soils such as clay and is due to malaria, which, as is well known, is caused by a minute parasite which lives in the blood and which may be cured by a proper use of quinine. The other anemia, preeminently a disease of the sandy regions, is caused by a parsitic 'hookworm' (*Uncinaria americana*) which lives in the intestine and which is not affected by quinine but can be killed by the use of thymol. These two anemias have heretofore been confused by most physicians, hence this

new discovery clears up a matter of great importance from the standpoint of the practising physician, and it is not an exaggeration to state that it means a revolution in the treatment of fully half of the sick people found in the southern sand areas.

One of the most important symptoms of 'hookworm' disease is an extreme lassitude, both mental and physical; this condition is due to the emaciation and to the thin watery character of the blood, which does not properly nourish either the brain or the muscles. Now, curiously enough, it is especially in the sand areas of the south that the poorer whites, known as the 'poor white trash,' are found, and Dr. Stiles, who has been living among these people for a number of weeks, positively states that it is among these people that hookworm disease is especially common and especially severe. He found entire families and entire neighborhoods affected, and owing to the symptoms which the disease causes, he asserts that this malady is very largely responsible for the present condition of these people. He states in fact that if we were to place the strongest class of men and women in the country in the conditions of infection under which these poorer whites are living, they would within a generation or two deteriorate to the same poverty of mind, body and worldly goods, which is proverbial for the 'poor white trash.'

It is true that the poorer whites are found on clay soils as well as on sand, but Dr. Stiles maintains that on clay soil these people are healthier, stronger and more intelligent, hence that they are better fitted for the competition in life, from which the hookworm disease practically excludes the poorer whites of the sand farms. He has further traced families from sand to clay or to the cities and proved their improvement under the new conditions; and conversely he has traced families from clay to sand and proved their deterioration.

An important point claimed in these investigations is that hookworm disease is especially prevalent among children, and that it not only interferes with their school attendance, but that children who are afflicted with the malady and who have gone from sandy districts to a city have the reputation among their teachers of being more or less backward and even stupid in their studies. All this agrees with well-established symptoms of the disease, for it is thoroughly established, not only by Dr. Stiles's investigations, but by observations in Europe and Africa, that hookworm diseases stunts both the physical and the mental development. Dr. Stiles states in fact that he has found patients of twenty to twenty-three years of age who both mentally and physically were not developed beyond the average boy or girl of eleven to sixteen years old.

There are other points in connection with this work, such as the perverted habit of dirt-eating, the presence of the disease among factory hands who formerly lived in the country, the financial loss involved, etc., into which we can not enter here at present. The happiest part of the entire work is that the disease can be easily prevented and that it can be cured. Under these circumstances, we may look for decided improvement among the poorer whites in the sand districts of the south, although this remark is not to be interpreted as meaning that we consider that 'hookworm disease' gives us a complete explanation of all ills in the southern states.

The full report of these investigations will be in the printers' hands this month and will be issued as a bulletin of the Hygienic Laboratory, U. S. Public Health and Marine Hospital Service.

CARNEGIE INSTITUTION OF WASHINGTON.

It is the purpose of the Carnegie Institution of Washington, among other plans, to encourage exceptional talent

by appointing a certain number of research assistants.

These positions will not be those commonly known as fellowships or scholarships; nor is the object of this provision to contribute to the payment of mechanical helpers or of assistants in the work of the institution. It is rather to discover and develop, under competent scrutiny and under favorable conditions, such persons as have unusual ability. It is not intended to provide means by which a student may complete his courses of study, nor to give assistance in the preparation of dissertations for academic degrees. Work of a more advanced and special character is expected of all who receive appointment.

The annual emolument will vary according to circumstances. As a rule, it will not exceed $1,000 per annum. No limitations are prescribed as to age, sex, nationality, graduation or residence. Appointments will at first be made for one year, but may be continued.

It is desirable that a person thus appointed should work under the supervision of an investigator who is known to the authorities of the Carnegie Institution to be engaged in an important field of scientific research, and in a place where there is easy access to libraries and apparatus—but there may be exceptions to this.

Applications for appointments may be presented by the head of, or by a professor in, an institution of learning, or by the candidate. They should be accompanied by a statement of the qualifications of the candidate, of the research work he has done, and of that which he desires to follow, and of the time for which an allowance is desired. If he has already printed or written anything of interest, a copy of this should be enclosed with the application.

Communications upon this subject should be distinctly marked on the outside envelope, and on the inside, Research Assistant, and should be addressed to the Carnegie Institution of Washington, 1439 K Street, Washington, D. C.

The Carnegie Institution has made a grant to the Marine Biological Laboratory and now has at its disposal twenty tables in the Laboratory at Woods Hole, Mass., for the season of 1903. These tables are intended for the use of persons engaged in original research in biology, and carry with them the right to be furnished with the ordinary supplies and material of the Laboratory. Applications for the use of one of these tables should be addressed to the Secretary of the Carnegie Institution, Washington, D. C., stating the period for which the use of the table is desired, and the general character of the work which the applicant proposes to do.

SCIENTIFIC ITEMS.

Dr. Carroll D. Wright, U. S. Commissioner of Labor, was elected president of the American Association for the Advancement of Science at the recent Washington meeting. The vice-presidents for the sections are: Section A, Mathematics and Astronomy, O. H. Tittmann, U. S. Coast and Geodetic Survey; B, Physics, E. H. Hall, Harvard University; C, Chemistry, W. D. Bancroft, Cornell University; D, Mechanical Science and Engineering, C. M. Woodward, Washington University; E, Geology and Geography, I. C. Russell, University of Michigan; F, Zoology, E. L. Mark, Harvard University; G, Botany, T. H. Macbride, University of Iowa; H, Anthropology, M. H. Saville, American Museum of Natural History; I, Social and Economic Science, S. E. Baldwin, New Haven; K, Physiology and Experimental Medicine, H. P. Bowditch, Harvard University.